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Revision 0

TANK FARM VADOSE ZONE CONTAMINATION: VOLUME ESTIMATES FOR RISK ASSESSMENTS

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APPENDIX

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LIST OF TERMS

BBI	best-basis inventory
bgs	below ground surface
DOE	U.S. Department of Energy
HDW	Hanford Defined Waste
HLW	high-level waste
LAW	low-activity waste
PUREX	Plutonium-Uranium Extraction
REDOX	reduction and oxidation
SIM	Soil Inventory Model
SST	single-shell tank
TBP	tributyl phosphate
TWINS	*Tank Waste Information Network System*
UPR	unplanned release
WIDS	*Waste Information Data System*
WMA	Waste Management Area

Units

Ci	curies
ft	feet
gal	gallons
in.	inch(es)
kgal	thousand gallons
Mgal	million gallons
pCi	picocuries
psi	pounds per square inch

1.0 INTRODUCTION

Over the past decade, there has been a significant effort to better understand and quantify vadose zone contamination in and around the single-shell tank (SST) farms. This effort included the following:

- Spectral gamma logging of available drywells in the SST farms
- Analysis of historical gross gamma logging data collected from 1974 through 1994 in the SST farms
- Review of available historical tank farm operational records and tank leak documentation field characterization in a number of the farms
- Science & Technology investigations that enhance the understanding of the interactions between tank waste materials and Hanford Site soils.

This report presents vadose contamination volume estimates for the Hanford Site tank farms that were developed as a result of previous investigations and documented in a number of studies referenced herein. These volume estimates are "best" estimates of the volume of contamination in the vadose zone and do not factor in uncertainties. Depending on the application, more conservative estimates or uncertainty estimates may be needed.

The volume estimates presented in this report were prepared in support of vadose zone inventory calculations for Hanford Site risk assessments. Calculations will be performed using the Soil Inventory Model (SIM). The SIM multiplies the contaminant volume for a waste loss event by an estimated waste composition to derive the inventory. Contaminant concentrations are determined based on the best available information for a waste loss event and waste type (BHI-01496, *Groundwater/Vadose Zone Integration Project: Hanford Soil Inventory Model*). The contaminant concentrations are derived from the Hanford Defined Waste Model (HDW) estimates (RPP-19822, *Hanford Defined Waste Model – Revision 5*). The SIM documentation will be updated to reflect these waste volumes, provide a technical basis for composition estimates used, and describe model verification and validation.

Sections 2.0 and 3.0 of this report focus on 67 assumed or confirmed leaking tanks (HNF-EP-0182, Rev 199, *Waste Tank Summary Report for Month Ending October 31, 2004*) in the SST farms. Aside from crib discharges, tank leaks are the major source of contamination in the vadose zone and have been the focus of the most previous vadose contamination studies. Section 2.0 provides tables showing leak volume estimates from the tanks or ancillary tank equipment assumed to contribute to the vadose inventory. A synopsis describing the basis for tank or ancillary tank equipment leak volume estimates is presented in Section 3.0 for the 67 "confirmed or assumed leaking tanks." More detailed discussions are presented in reports referenced. For some tanks, little or no basis for previous leak volume estimates was found. However, some tank leak events and volume estimates are well documented.

A list of currently documented unplanned releases (UPR) and near-surface contamination volume estimates for UPRs are presented in Section 4.0. Except as noted, the near-surface losses presented in this report are those currently included in the SIM. Although extensive surface contamination is found in some farms, in general, the volume of waste from UPRs is a small fraction of the total volume from tank leaks and ancillary equipment.

An estimate of crib discharges within tank farm Waste Management Areas (WMA) are assumed to add to the contamination in a WMA and is presented in Section 5.0. Millions of gallons of waste were discharged to two cribs in WMA T and WMA TX/TY. Other crib discharges were also substantial, but are assumed to be outside tank farm WMAs and were not included in this report.

Extensive work is ongoing to better characterize vadose contamination. Volume estimates presented in this report are expected to change and will be updated as additional characterization data is made available and a better understanding of vadose contamination is obtained.

2.0 TANK LEAK ESTIMATES IN SINGLE-SHELL TANK FARMS

Sixty-seven of Hanford's 149 SSTs are listed as "confirmed or assumed leakers" in the *Waste Tank Summary Report for Month Ending October 31, 2004* (HNF-EP-0182, Rev. 199). Much of the tank leak information in the *Waste Tank Summary Report* was compiled in the late 1980s and reflects the state of knowledge at that point in time. Leak volume estimates are of varying quality; for example, the leak volumes for SSTs SX-113, SX-115, and T-106 are well documented; however, for 19 tanks there is essentially no information to determine a leak volume estimate and little evidence why these tanks are considered "assumed leakers."

Some of the tank leaks listed in HNF-EP-0182 may be associated with waste transfer system waste loss events and tank overfill events rather than failure of the tank itself. These events are described in the following documents:

- RPP-6285, *Inventory Estimates for Single-Shell Tank Leaks in S and SX Tank Farms*
- RPP-7218, *Preliminary Inventory Estimates for Single-Shell Tank Leaks in T, TX, and TY Tank Farms*
- RPP-7389, *Preliminary Inventory Estimates for Single-Shell Tank Leaks in B, BX, and BY Tank Farms*
- RPP-7884, *Field Investigation Report for Waste Management Area S-SX*
- RPP-10098, *Field Investigation Report for Waste Management Area B/BX/BY*
- RPP-15808, *Subsurface Conditions Description of the U Waste Management Areas*.

Over the past decade, vadose investigations have focused on developing a better understanding of major SST leaks and developing an understanding of the potential impacts of SST leaks on groundwater quality. Since, for all practical purposes, it is impossible to demonstrate that any SST did not leak, the vadose zone team efforts have focused on better defining the impacts of "tank farm operations" on the vadose zone. These impacts include past leaks from SSTs, SST overfills, and piping and infrastructure waste loss events.

The vadose zone characterization effort included field drilling, sampling, and soil analysis in multiple SST farms coupled with research and review of historical process records and gamma logging data. These efforts integrated information from a number of U.S. Department of Energy (DOE) Hanford-related projects and focused on evaluating the tank leak events that contribute the bulk of subsurface contamination. The following sources of information were used for this report:

- Spectral gamma logging data from drywells
- Analysis of historical gross gamma logging data collected from 1974 through 1994
- Review of historical tank farm operations records
- Review of historical process chemistry records from Hanford Site facilities
- Results from vadose zone characterization in WMA S/SX
- Studies of cesium sorption chemistry in Hanford Site soils
- Studies of moisture movement and unsaturated flow characteristics in Hanford Site soils.

2.1 GROSS GAMMA AND SPECTRAL GAMMA LOGGING DATA

These information sources include baseline spectral gamma logging of all of the drywells within each of the 12 SST farms as well as assessments of the historical gross gamma logging data from each SST farm. The results from the baseline spectral gamma logging project are summarized in 12 MACTEC-ERS spectral gamma logging tank farm reports (one for each SST farm) hereafter referred to collectively as the MACTEC reports. Analysis and summaries of the gross gamma logging data also are reported by tank farm. Reference information for the MACTEC analysis and summary reports is listed in Table 2-1.

Table 2-1. Spectral Gamma Logging Tank Farm Reports. (2 sheets)

Report	Title
GJO-HAN-6/GJO-96-2-TAR	*Vadose Zone Characterization Project at the Hanford Tank Farms, BY Tank Farm Report*
GJO-HAN-8/GJO-97-1-TAR	*Vadose Zone Characterization Project at the Hanford Tank Farms, U Tank Farm Report*
GJO-HAN-11/GJO-97-13-TARA	*Hanford Tank Farms Vadose Zone, TX Tank Farm Report*
GJO-HAN-12/GJO-97-14-TARA	*Addendum to the AX Tank Farm Report*
GJO-HAN-16/GJO-97-30-TAR	*Hanford Tank Farms Vadose Zone: TY Tank Farm Report*

Table 2-1. Spectral Gamma Logging Tank Farm Reports. (2 sheets)

Report	Title
GJO-HAN-18/GJO-98-39-TARA	*Hanford Tank Farms Vadose Zone: C Tank Farm Report*
GJO-HAN-19/GJO-98-40-TAR	*Hanford Tank Farms Vadose Zone: BX Tank Farm Report*
GJO-HAN-23/GJO-98-64-TAR	*Hanford Tank Farms Vadose Zone: A Tank Farm Report*
GJO-HAN-27/GJO-99-101-TARA	*Hanford Tank Farms Vadose Zone: T Tank Farm Report*
GJO-HAN-28/GJO-99-113-TAR	*Hanford Tank Farms Vadose Zone: B Tank Farm Report*
GJO-HAN-17/GJO-97-31-TAR	*Hanford Tank Farms Vadose Zone: S Tank Farm Report*
GJPO-HAN-4/DOE/ID/12584-268	*Vadose Zone Characterization Project at the Hanford Tank Farms, SX Tank Farm Report*
RPP-8820, Rev. 0	*Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-A Tank Farm – 200 East*
RPP-8821, Rev. 0	*Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-AX Tank Farm – 200 East*
HNF-5433, Rev. 0	*Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-B Tank Farm – 200 East*
HNF-3531, Rev. 0	*Analysis of Historical Gross Gamma Logging Data from BX Tank Farm*
HNF-3532, Rev. 0	*Analysis of Historical Gross Gamma Logging from BY Tank Farm*
RPP-8321, Rev. 0	*Analysis and Summary Report of Historical Dry Well Gamma Logging Logs for the 241-C Tank Farm – 200 East Area*
HNF-4220, Rev. 0	*Analysis and Summary of Historical Dry Well Gamma Logs for S Tank Farm – 200 West*
HNF-3136, Rev. 0	*Analysis Techniques and Monitoring Results, 241-SX Drywell Surveillance Logs*
RPP-6088, Rev. 0	*Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-T Tank Farm – 200 West*
RPP-6353, Rev. 0	*Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-TX Tank Farm – 200 West*
HNF-3831, Rev. 0	*Analysis of Historical Gross Gamma Logging Data from 241-TY Tank Farm*
RPP-7729, Rev. 0	*Analysis and Summary Report of Historical Dry Well Gamma Logging Logs for the 241-U Tank Farm – 200 West Area*

2.2 SINGLE-SHELL TANK FARM FIELD INVESTIGATIONS

A Summary and Evaluation of Hanford Site Tank Farm Subsurface Contamination (HNF-2603) provides the technical basis for the tank farm vadose investigations. Since the publication of HNF-2603, several dozen additional technical documents have been released that track progress in the tank farm vadose characterization efforts (RPP-7884 and RPP-10098). An active drilling program is underway in WMAs T, TX-TY, and C (RPP-7578, *Site-Specific SST Phase 1*

RFI/CMS Work Plan Addendum for WMAs T, TX and TY) as well as planning for field investigations in the C, A, AX, and U tank farms (RPP-14430, *Subsurface Conditions Description of the C and A-AX Waste Management Area*).

2.3 RELATIONSHIP BETWEEN LOGGING DATA AND TANK LEAKS

The baseline spectral gamma logging data collected from all drywells within the SST farms provide a useful window for interpreting tank leak information. The relationship between the leak status of SSTs and spectral gamma logging data in nearby drywells is qualitative; however, both the depth of gamma activity and its intensity provide some ability to distinguish between failure of the tank and losses associated with piping or tank overfills. Most easily distinguished are cases where waste volume decreases correspond to high ^{137}Cs activity in one or more nearby drywells. In these cases, ^{137}Cs activity is often approximately 1×10^8 pCi/g. Depending on the waste type present, there are frequently other gamma emitters at much lower concentrations. If the high ^{137}Cs activity zones appear at or near the levels of the waste transfer lines or SST spare inlet ports, then this is considered evidence of a piping leak or tank overfill event as being the origin of the contamination. As a rule of thumb, ^{137}Cs activity on the order of 10,000 pCi/g or higher (see NOTE 1) beginning near the base of the tank is a strong indication of a tank leak. Lower cesium activity further away from a tank is much more difficult to interpret.

NOTE 1 - The selection of 10,000 pCi/g ^{137}Cs is a judgment call. The rationale for selecting a high ^{137}Cs value is based on cesium sorption chemistry in Hanford Site soils. For background information on this subject refer to RPP-7884, Appendix D. Work by Zachara and coworkers show that cesium is strongly sorbed on Hanford Site soils. Thus, even a dilute solution of ^{137}Cs discharged to the same point in the soil column would lead to high-activity levels in the soil if sufficient volumes were discharged. Based on the extensive spectral gamma logging database and a limited soil analysis data set, the "effective ^{137}Cs sorption capacity" of Hanford Site soils appears to be in the range of 1E+07 to 1E+08 pCi/g. The mechanism of cesium movement in the subsurface appears to depend on first saturating the available active sites on the soil particles prior to plume movement. This mechanism is of course constrained by the sorption kinetics. The bottom line is that one expects to find high ^{137}Cs activity in any soil penetrated by sufficient volumes of any waste containing ^{137}Cs.

Low levels of ^{137}Cs contamination are common in drywells around most SSTs. Open boreholes may have provided a pathway for contamination to enter the well casing, and in some cases, the unsealed boreholes could have provided a pathway for contamination to move downward. In addition, the compacted base on the original tank farm excavation provided a region for liquids to pond and move laterally. The cesium-sorption chemistry predicts that the ^{137}Cs is in a highly concentrated plume with sharp activity drops at the edge (RPP-7884). Thus, when low ^{137}Cs activity is reported in one of the drywells it appears there are only two reasonable explanations: (1) Either the drywell is sitting on the edge of a high-activity ^{137}Cs plume, or (2) the contamination was the result of a lower activity gamma contamination spread from routine operations. Distinguishing between the two options requires an assessment of other information such as waste transfer and waste level records, waste type in the tank, documented leak history, and data from nearby drywells.

An understanding of the waste type involved in any type of release to the soil column is critical in developing a useful inventory estimate. Within reason, the type of waste lost is more important than the volume of waste lost. Typically, the ^{137}Cs was around 30 Ci/gal in the Plutonium-Uranium Extraction (PUREX) high-level waste (HLW) stream (ISO-100, *Waste Management Technical Manual*). For comparison, the waste stream generated from the dissolution of the aluminum cladding from the irradiated fuel rods carried about 0.003 Ci/gal of ^{137}Cs (LA-UR-96-3860, *Hanford Tank Chemical and Radionuclide Inventories*: *HDW Model Rev. 4*). Thus, a 1,000-gal loss of cladding waste would release approximately 3 Ci of ^{137}Cs, whereas a 1,000-gal loss of a typical PUREX HLW would release approximately 30,000 Ci of ^{137}Cs. Other radionuclides present in the fuel rods would be released in proportional amounts. Thus, the waste type is important to estimating leak inventories.

2.4 REVISED LEAK VOLUME ESTIMATES

The tank/ancillary equipment leak volumes were updated based on investigation and review of past tank data. Table 2-2 shows a comparison of the SST leak volumes reported in HNF-EP-0182 and revised leak volumes for risk assessments.

As previously noted, the quality of tank leak estimates varies significantly. Some leaks are large with high-activity levels and have a strong documented technical basis. Others are “assumed” or “questionable” and little or no data is available to estimate a leak inventory. Past tank leak estimates within the SST farms have been binned into four quality groups. Table 2-2 identifies the quality of volume estimates for 68 SSTs.

Table 2-2. Comparison Between HNF-EP-0182 Volume Estimates and Revised Leak Volume Estimates. (5 sheets)

Tank	HNF-EP-0182, (October 2004) leak volume (gal)	Revised leak volume (gal)	Quality of estimate (Bin)**	Basis for revised estimate
A-103	5,500	5,500	2	Based on unexplained liquid-level decreases identified in 1987. Assumes no evaporation. (Section 3.1.1).
A-104	500 to 2,500	2,000	1	HNF-EP-0182 and SD-WM-SAR-006 list an estimated leak volume of between 500 and 2,500 gal. (Section 3.1.2)
A-105	10,000 to 277,000	1,000	3	The higher range in the HNF-EP-0182 estimates consists mostly of cooling water that was added to the tank between 1970 and 1978, much of which is thought to have been lost through evaporative cooling. An estimated 21,000 gal of sludge remains between the liner and tank wall. Based on minimal gamma activity in surrounding drywells and laterals, and historical records of the 1965 “steam event”, the loss of PUREX HLW to the vadose zone is assumed to be minimal, thus a value of 1,000 gal is assigned. (Section 3.1.3)

Table 2-2. Comparison Between HNF-EP-0182 Volume Estimates and Revised Leak Volume Estimates. (5 sheets)

Tank	HNF-EP-0182, (October 2004) leak volume (gal)	Revised leak volume (gal)	Quality of estimate (Bin)**	Basis for revised estimate
AX-102	3,000	3,000	2	Contamination likely originated from a near-surface leak thought to be associated with condensate from the off-gas header joint. (Section 3.1.4)
AX-104	---- *	0	4	No basis for leak volume estimate. (Section 3.1.5)
B-101	---- *	0	4	No basis for leak volume estimate. (Section 3.2.1)
B-103	---- *	0	4	No basis for leak volume estimate. (Section 3.2.2)
B-105	---- *	0	4	No basis for leak volume estimate. (Section 3.2.3)
B-107	8,000	14,000	1	Waste transfer data indicates a larger leak volume than previously assumed. (Section. 3.2.4)
B-110	10,000	10,000	2	Leak source is near transfer lines. (Section 3.2.5)
B-111	---- *	0	4	No basis for leak volume estimate. (Section 3.2.6)
B-112	2,000	2,000	2	Drywell contamination may be from SST B-110 plume. (Section 3.2.7)
B-201	1,200	1,200	2	224 waste with comparatively low radioactivity. Contribution to inventory is minor. (Section 3.2.8)
B-203	300	300	2	224 waste with comparatively low radioactivity. Contribution to inventory is minor. (Section 3.2.8)
B-204	400	400	2	224 waste with comparatively low radioactivity. Contribution to inventory is minor. (Section 3.2.8)
BX-101	---- *	4,000	1	Leak volume estimate based on spectral gamma logging. (Section. 3.2.9)
BX-102	70,000	91,600	1	Revised inventory estimate based on 1951 tank overfill event. (Section 3.2.10)
BX-108	2,500	2,500	2	Based on unexplained liquid-level decreases. Assumes no evaporation. (Section 3.2.11)
BX-110	---- *	0	4	No basis for leak volume estimate. (Section 3.2.11)
BX-111	---- *	0	4	No basis for leak volume estimate. (Section 3.2.11)
BY-103	<5,000	**	4	Extensive near-surface contamination. Included as part of BY tank farm contamination estimate. (Section 3.2.12)
BY-105	---- *	0	4	No basis for leak volume estimate. (Section 3.2.12)
BY-106	---- *	0	4	No basis for leak volume estimate. (Section 3.2.12)
BY-107	15,100	**	4	Extensive near-surface contamination. Included as part of BY tank farm contamination estimate. (Section 3.2.12)
BY-108	<5,000	**	4	Extensive near-surface contamination. Included as part of BY tank farm contamination estimate. (Section 3.2.12)

Table 2-2. Comparison Between HNF-EP-0182 Volume Estimates and Revised Leak Volume Estimates. (5 sheets)

Tank	HNF-EP-0182, (October 2004) leak volume (gal)	Revised leak volume (gal)	Quality of estimate (Bin)**	Basis for revised estimate
C-101	20,000	1,000	3	Some or all liquid-level decrease may be due to evaporation. High radioactivity not observed in drywell system or laterals. (Section 3.3.1)
C-105	Not Listed	1,000	1	High ^{137}Cs plume near base of tank. Probably from a transfer line leak. (Section 3.3.2)
C-110	2,000	2,000	2	May be attributed to tank overfill. Not observed in drywell system. (Section 3.3.3)
C-111	5,500	5,500	2	Not observed in drywell system. Assumes no evaporation (Section 3.3.4)
C-201	550	550	2	Hot-semiworks PUREX. Contribution to inventory is minor. Assumes no evaporation. (Section 3.3.5)
C-202	450	450	2	Hot-semiworks PUREX. Contribution to inventory is minor. Assumes no evaporation. (Section 3.3.5)
C-203	400	400	2	Hot-semiworks PUREX. Contribution to inventory is minor. Assumes no evaporation. (Section 3.3.5)
C-204	350	350	2	Hot-semiworks PUREX. Contribution to inventory is minor. Assumes no evaporation. (Section 3.3.5)
S-104	24,000	24,000	1	Leak volume consistent with waste transfer records. Assumes no evaporation. (Section 3.4.1)
SX-104	6,000	6,000	2	Assumed leak would have involved high-activity REDOX cesium recovery waste type. No evidence of this waste or level of activity in the vadose zone. Assumes no evaporation. (Section 3.4.2)
SX-107	<5,000	15,000	1	Revised leak volume estimate based on vadose zone data analysis. (Section. 3.4.3)
SX-108	2,400 – 35,000	35,000	1	Upper range of volume estimate selected based on vadose zone data analysis. (Section. 3.4.3)
SX-109	<10,000	2,000	1	Revised leak volume estimate based on vadose zone data analysis. (Section. 3.4.3)
SX-110	5,500	1,000	3	Revised leak volume estimate based on vadose zone data analysis. Assumed leak would have involved high-activity REDOX cesium recovery waste type. No evidence of this waste or level of activity in the drywells or laterals and no evidence of losses in transfer records. (Section 3.4.4)
SX-111	500	500	2	No evidence in vadose zone drywells and only one lateral indicates potential leak. Based on increased activity in center lateral. (Section 3.4.5)
SX-112	30,000	1,000	3	Assumed leak would have involved REDOX HLW and significantly higher activity levels are expected in the drywells and laterals for a leak of this magnitude. Liquid-level losses can be explained by

Table 2-2. Comparison Between HNF-EP-0182 Volume Estimates and Revised Leak Volume Estimates. (5 sheets)

Tank	HNF-EP-0182, (October 2004) leak volume (gal)	Revised leak volume (gal)	Quality of estimate (Bin)**	Basis for revised estimate
				transfers. (Section 3.4.6)
SX-113	15,000	15,000	1	Tank bulge observed. Volume loss confirmed as part of leak test. (Section 3.4.7)
SX-114	---- *	0	4	No basis for leak volume estimate. (Section 3.4.8)
SX-115	50,000	50,000	1	Based on an 18-in. liquid-level decrease. (Section 3.4.9)
T-101	7,500	10,000	1	Revised leak volume estimate based on transfer records. (Section. 3.5.1)
T-103	<1,000	3,000	1	Revised leak volume estimate based on tank transfer records. (Section 3.5.2)
T-106	115,000	115,000	1	Based on over 41-in. liquid-level decrease. Largest recorded leak at the Hanford Site. (Section. 3.5.3)
T-107	---- *	0	4	No basis for leak volume estimate. (Section 3.5.4)
T-108	<1,000	1,000	2	Leak volume may be from SST T-106. (Section 3.5.5).
T-109	<1,000	1,000	2	Leak volume may be from SST T-106. (Section 3.5.6).
T-111	<1,000	1,000	2	Leak volume may be from SST T-106. (Section 3.5.7).
TX-105	---- *	0	4	No basis for leak volume estimate. (Section 3.5.8)
TX-107	2,500	8,000	1	Revised leak volume estimate based on waste transfer records and drywell gamma monitoring. (Section 3.5.9)
TX-110	---- *	0	4	No basis for leak volume estimate. (Section 3.5.10)
TX-113	---- *	0	4	No basis for leak volume estimate. (Section 3.5.10)
TX-114	---- *	0	4	No basis for leak volume estimate. (Section 3.5.10)
TX-115	---- *	0	4	No basis for leak volume estimate. (Section 3.5.10)
TX-116	---- *	0	4	No basis for leak volume estimate. (Section 3.5.10)
TX-117	---- *	0	4	No basis for leak volume estimate. (Section 3.5.10)
TY-101	<1,000	1,000	2	Spectral gamma drywell data indicates potential near-surface leaks. (Section 3.5.11)
TY-103	3,000	3,000	1	Based on liquid-level decrease and drywell activity. (Section 3.5.12)
TY-104	1,400	1,400	2	No waste transfer or vadose monitoring basis for leak volume estimate. Extensive near-surface contamination suggests possible piping transfer leak. (Section 3.5.13)
TY-105	35,000	35,000	1	Based on waste transfer records and drywell activity. (Section 3.5.14)

Table 2-2. Comparison Between HNF-EP-0182 Volume Estimates and Revised Leak Volume Estimates. (5 sheets)

Tank	HNF-EP-0182, (October 2004) leak volume (gal)	Revised leak volume (gal)	Quality of estimate (Bin)**	Basis for revised estimate
TY-106	20,000	20,000	1	Confirmed leaker stabilized with diatomaceous earth. Drywell activity. (Section 3.5.15)
U-101	30,000	5,000	3	Assumed leak would have involved REDOX HLW. Not observed in drywell system. Value set to detection limit of system based on results of field test. (Section 3.6.1)
U-104	55,000	55,000	1	Based on drywell contamination and liquid-level decrease. (Section 3.6.2)
U-110	5,000 – 8,100	6,500	1	Based on liquid-level decrease and increased drywell activity. (Section 3.6.3)
U-112	8,500	8,500	1	Based on liquid-level decrease and drywell activity. (Section 3.6.4)

Notes:

* The leak volume estimates in HNF-EP-0182 for the tanks were based on an assumption that their cumulative leakage is approximately the same as for 18 of the 24 tanks where leak volumes were determined by liquid-level decreases. SSTs SX-110 and T-106 were considered atypical and were not included. SSTs B-201, 203, 204, and C-203, also excluded, are small 200-series diameter tanks. The 18 tank leak estimates that were included in the estimate were SSTs A-103, AX-102, B-107, B-110, BY-107, C-101, C-111, S-104, SX-104, SX-109, T-103, T-108, T-109, T-111, TY-101, TY-104, U-110, and U-112 (8901832B). The total liquid loss assumed for the 19 tanks was 150,000 gal, an average of approximately 8,000 gal/tank.

**Tank leak estimates were placed in 1 of 4 categories:

1 - Well known and documented.

2 - Small leaks no clear basis for inventory estimates.

3 - No evidence of higher leak volume in vadose zone, nominal or de-minimus volume assumed.

4 - No leak volume estimates possible.

***Tank leak estimates for BY tank farm are combined in a total tank farm vadose estimate of 1,160 Ci of ^{137}Cs. The estimate is based on 1996 measurements. A volume estimate will be derived from this using the SIM.

HNF-EP-0182, 2004, *Waste Tank Summary Report for Month Ending October 31, 2004*, Rev. 199, CH2M HILL Hanford Group, Inc., Richland, Washington.

BBI= best-basis inventory.
HLW = high-level waste.
PUREX = plutonium-uranium extraction.
REDOX = reduction and oxidation.
SIM = Soil Inventory Model.
UPR = unplanned release.
WSTRS = Waste Status and Transaction Record Summary.

2.4.1 Bin 1

The 21 tanks in Bin 1 are tanks with leak volumes and inventories that are well documented and consistent with tank records, geophysical records, and other sources of information. Tank leak estimates assigned to this bin either remained the same or increased as a result of recent vadose zone investigations.

2.4.2 Bin 2

There are 21 tanks listed in Bin 2. A “leak volume” for these tanks is shown in HNF-EP-0182 based on liquid-level decreases but inventories previously have not been developed. In general, the leak volumes reported are smaller than leak volumes that normally would be detected in the vadose zone (see Appendix A). In some cases, the “leak” appears to have originated near surface. The logic leading to the estimates vary in both level of sophistication and reproducibility. Leak volume estimates in this category generally are too small to be supported by vadose estimates or technical arguments and appear to be conservative. However, (1) information available at the time - but not recorded in a retrievable archive; (2) loss of key personnel over the years; and (3) the small size of many of the leaks make any current formal reevaluation likely to yield questionable results. Because new field data does not add new information to validate or change these estimates, the leak volume estimates shown in HNF-EP-0182 will be used and inventory estimates developed based on liquid waste types in a tank when liquid-level decreases occurred for that tank.

2.4.3 Bin 3

Bin 3 includes five SSTs on the “confirmed or suspected” leaker list for which new information indicates that previous leak volume estimates are high. New information has been developed regarding the spreading characteristics of liquids in the vadose zone and thus a better understanding of the ability of the existing ex-situ detection system to detect larger leaks – particularly those leaks containing reduction/oxidation (REDOX) or PUREX HLW. Leak volume estimates for five tanks were reduced to “de-minimus” volumes. These tanks included SSTs A-105, C-101, SX-110, SX-112, and U-101. Previous leak volume estimates for these tanks were 10 kgal, 20 kgal, 5.5 kgal, 30 kgal, and 30 kgal, respectively (HNF-EP-0182), and involve REDOX or PUREX HLW. Given the understanding of fluid-flow in the Hanford Site’s unsaturated soils, it is highly unlikely that a leak volume of these magnitudes could have gone undetected by the secondary leak monitoring (i.e., the drywell gross gamma logging) system (see discussion below). At the time of the apparent liquid losses from these tanks, the tanks held high-heat wastes that recently had been transferred from “boiling waste” tanks. Thus, evaporative cooling likely accounts for most or all of the liquid-level decreases in these tanks.

A “de-minimus” leak volume was set for SST U-101 at the detection limit of the ex-situ detection system. The “de-minimus” volume was determined from an evaluation of data collected at a field test site and complemented by the study of other large and well documented tank leaks (see Appendix A). The expected leak detection limit was determined to be approximately 5,000 gal.

The leak volume estimates for SSTs A-105, SX-110, and SX-112 were reduced to a nominal value of 1,000 gal based on the level of contamination discovered in the laterals immediately below the tanks (see Sections 3.1.3 and 3.4.6). Much greater levels of contamination should have been detected in the laterals if the magnitude of the leak was greater than 1,000 gal for these tanks. Additional characterization is planned to further evaluate vadose contamination for these tanks.

The leak volume estimate for SST C-101 was also a nominal 1,000 gal. This is because there is no data indicating a tank leak in the vadose zone and heat load estimates indicate that most of the losses from this tank may be due to evaporation (see Section 3.3.1)

2.4.4 Bin 4

Bin 4 includes 18 of the 19 tanks and 3 additional assumed leakers in BY tank farm (SSTs BY-103, BY-107, and BY-108).

Little information is available for 18 of the 19 tanks to support a leak volume estimate and no previous leak estimate has been developed other than assuming an average value based on previous tank leaks from 18 other tanks (8901832B, "Single-Shell Tank Leak Volumes"). For these tanks, small levels of contamination (much smaller than plumes for typical tank leaks; tanks in Bin 1) were observed in nearby drywells. The contamination may have come from a tank or from near-surface releases or other sources. In any case, neither the waste type and source of the drywell activity nor the date when it first occurred are known; both of which are needed to determine a credible inventory estimate. Therefore, any inventory associated with contamination from these tanks is assumed negligible or accounted for by leak estimates for tanks in the other three bins or UPR estimates. No attempt was made to develop inventories for these 18 tanks.

Tanks and surface-level contamination in BY tank farm are intermixed and make it difficult to distinguish which tanks leaked and how much. However, vadose data shows extensive ^{137}Cs surface (top 0 to 40 ft) contamination in BY tank farm attributed to tank leaks, pipeline losses and spills (Section 3.2.12). These pipeline leaks and spills are not accounted for by the UPRs shown in Section 5.0. Therefore, in place of questionable and highly uncertain individual tank leak estimates and possible overlap or duplication in a single BY tank farm vadose zone, a ^{137}Cs inventory was developed from spectral gamma logging data. Rationale and calculations for the BY tank farm vadose zone inventory estimate are presented in Sections 3.2.12 and 5.0.

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3.0 TANK-BY-TANK DISCUSSION OF LEAK VOLUME ESTIMATES

This section summarizes the technical basis for leak volume inventory estimates in Table 2-2 for 68 SSTs. These leak estimates may include losses from ancillary equipment, spills or overflows from the tank, and are not confined to tank leaks.

3.1 LEAK VOLUME ESTIMATES FOR A AND AX TANK FARMS

Three of the SSTs in the A tank farm (A-103, A-104, and A-105) and two of the SSTs in AX tank farm (AX-102 and AX-104) are classified as assumed or confirmed leakers (HNF-EP-0182).

3.1.1 Single-Shell Tank 241-A-103

SST A-103 was declared an assumed leaker in 1987 based on liquid-level decreases. A leak evaluation panel (65950-87-326, "Tank 103-A Integrity Evaluation") determined that a leak was one of several possible explanations for the liquid-level decrease. Spectral gamma measurements have been recorded in drywells around the tanks in A tank farm and in lateral boreholes placed horizontally (about 3 m [10 ft] below the tank bottom) under each of the tanks. Historical reports (SD-WM-TI-356, *Waste Storage Tank Status and Leak Detection Criteria*) identify gross gamma radiation at the bottom of drywells around SST A-103. However, current spectral gamma data show little or no contamination at these drywells or boreholes. Lacking additional data, the original leak estimate of 5,500 gal based on liquid-level decreases is used. This tank leak was identified in 1987. At that time, the tank contained double-shell slurry feed , which is a concentrated salt solution derived from evaporation of the B Plant cesium ion exchange waste or other miscellaneous salt solutions.

3.1.2 Single-Shell Tank 241-A-104

The primary evidence of tank waste leaks from SST A-104 is provided by measurements of increased radiation in two laterals under the tank in 1975. Eventually, radiation was measured in the third lateral borehole as well. Evaluation of the gross gamma logs (RPP-8820, *Analysis and Summary Report of Historical Dry Well Gamma Logs for the 241-A Tank Farm – 200 East*) shows ^{106}Ru as a primary gamma emitter. The variable locations of radiation detection under the tank may indicate multiple leak locations. However, the extent of contamination that has entered into the vadose zone appears to be limited given the lack of contamination in adjacent drywells. HNF-EP-0182 and *Single-Shell Tank Isolation Safety Analysis Report* (SD-WM-SAR-006) list an estimated leak volume of between 500 and 2,500 gal. Discussions in the *Tank Summary Data Report for Tank A-104* (GJ-HAN-109) indicate that the leak was noted in 1975 during attempts to sluice PUREX HLW sludge from that tank. The tank was pumped to a minimum heel and taken out of service (LA-UR-96-3860).

3.1.3 Single-Shell Tank 241-A-105

The most serious waste-loss event from WMA A-AX occurred in SST A-105 in January 1965 (ARH-78, *PUREX TK-105-A Waste Storage Tank Liner Instability and Its Implications on Waste Containment and Control*). The tank was filled to capacity with PUREX HLW in a boiling state. The extremely high-heat load led to an intense steam release event that lasted for 30 minutes and resulted in a maximum 4-in. drop in the waste level in the tank. This event also caused a bulge in the bottom inner liner upward to an estimated 8.5 ft at one point and ripped the liner away from the sidewall. The tank was closely monitored for several years with no evidence of additional leakage. However, some liquid-level losses were noted during the final attempt to sluice the hard heel from the tank. Following the unsuccessful attempt to remove the hard heel, water was added to the tank for evaporative cooling for almost a decade.

The current leak volume estimate of this event is approximately 10,000 to 45,000 gal prior to November 1970 and up to 262,000 gal of cooling water (HNF-EP-0182). However, the spectral gamma logging data are inconsistent with a 10,000-gal loss of PUREX HLW from SST A-105 to the soil. Analytical data show that the ^{137}Cs concentration in SST A-105 supernatant at the time of the steam release event was 8.1 Ci/L (31 Ci/gal) (ARH-78). Thus, a 10,000-gal leak volume would require that 310,000 Ci of ^{137}Cs were lost to the soil column. Yet the drywells around SST A-105 have only very low levels of ^{137}Cs contamination (< 100 pCi/g). A 1977 study (Woodward-Clyde 1978, *An Estimate of Bottom Topography, Volume and other Conditions in Tank 105A, Hanford, Washington*) estimated that 21 kgal of sludge was between the bulged liner and the tank wall. This sludge waste is part of the in-tank best-basis inventory (BBI) estimates (*Tank Waste Information Network System* [TWINS] 2004).

Based on the level and extent of contamination observed in the vadose zone (GJO-HAN-23, *Hanford Tank Farms Vadose Zone: A Tank Farm Report*) and studies indicating 21 kgal of waste is trapped between the liner and tank wall a nominal volume of 1,000 gal of PUREX high-level supernatant in the vadose zone was assumed.

Attempts to re-log the laterals under SST A-105 using a spectral gamma logging tool are part of the A tank farm vadose zone investigations. Such data will further quantify the ^{137}Cs plume in the soil directly below the tank.

3.1.4 Single-Shell Tank 241-AX-102

Classification of SST AX-102 as an assumed leaker was based on several occurrence reports beginning in 1975 of slight liquid-level drops, slight increases in borehole activity, and an increase in the leak detection pit activity. Gamma profiles support the assumption that leaks were from coupling connections between a 20-in. vapor line and a 24-in. exhaust vapor header attached to the tank (GJO-HAN-12, *Hanford Tank Farms Vadose Zone: Addendum to the AX Tank Farm Report* and GJ-HAN-50, *Tank Summary Data Report for Tank AX-102*). A leak in the vapor line coupling would have resulted in the discharge of radioactively contaminated condensate to the soil. The leak volume estimate for this event is 3,000 gal based on liquid-level decreases in the tank.

3.1.5 Single-Shell Tank 241-AX-104

SST AX-104 was classified as an assumed leaker in 1977 based on several occurrence reports describing increased activity in nearby drywells. However, neither tank liquid level, leak detection pit liquid level, nor radiation monitoring gave any indication of tank leakage (HNF-SD-HTI-TI-001, *AX Tank Farm Waste Inventory Study for the Hanford Tanks Initiative Project*). The gross gamma activity records measured increased activity around the tank bottom level but these were brief in duration and of poor quality (GJO-HAN-12). The spectral gamma data from surrounding drywells show no levels of elevated activity. Through subsequent investigation, the source of the contamination was attributed to leaks from the exhaust vapor header similar to the SST AX-102 leak.

Based on the lack of a liquid-level decrease and minimal drywell activity near SST AX-104 a leak volume estimate was not determined.

3.2 LEAK VOLUME ESTIMATES FOR B, BX, AND BY TANK FARMS

Ten SSTs in B tank farm including three 200-series tanks (B-101, B-103, B-105, B-107, B-110, B-111, B-112, B-201, B-203, B-204), five SSTs in BX tank farm (BX-101, BX-102, BX-108, BX-110, BX-111), and five SSTs in BY tank farm (BY-103, BY-105, BY-106, BY-107, BY-108) are classified as assumed or confirmed leakers (HNF-EP-0182). Of these, SSTs B-107, BX-101, and BX-102 are the best quantified and primary leak sources for WMA B/BX/BY.

3.2.1 Single-Shell Tank 241-B-101

SST B-101 was classified as an assumed leaker based on gross gamma activity detected in a number of drywells around this tank and an apparent steady liquid-level decrease that was observed in 1974 (GJ-HAN-112, *Tank Summary Data Report for Tank B-101*). However, no leak volume is suggested for SST B-101.

3.2.2 Single-Shell Tank 241-B-103

SST B-103 was classified as an assumed leaker based on gross gamma activity detected in a number of drywells around this tank (GJ-HAN-114, *Tank Summary Data Report for Tank B-103*). The waste transfer records (LA-UR-97-311) provide no indication of unexplained liquid loss from this tank. The spectral gamma logging data reported in GJ-HAN-114 show very little gamma activity below 25 ft below ground surface (bgs). The maximum ^{137}Cs activity in these drywells is < 100 pCi/g. Gross gamma activity observed in 1978 in two drywells (20-03-03 and

20-03-06) at the base of the construction excavation was not detected in the 1998 spectral gamma logging data indicating that it was likely ^{106}Ru or some other mobile gamma-emitting radionuclide. No leak volume is suggested for SST B-103.

3.2.3 Single-Shell Tank 241-B-105

SST B-105 was classified as an assumed leaker in 1978 based on gross gamma activity detected in two nearby drywells (HNF-4872, *Single-Shell Tank Leak History Compilation*), but no leak volume was estimated (HNF-EP-0182). The gross gamma logging data (HNF-5433, *Analysis and Summary Report of Historical Dry Well Gamma Logs for 241-B Tank Farm – 200 East Area*) and spectral gamma logging data (GJ-HAN-126, *Tank Summary Data Report for Tank B-105*) report gamma activity at the level of the base of the tank in two drywells, 20-05-06 and 20-06-06. However, the waste transfer records (LA-UR-97-311) provide no indication of unexplained liquid loss from this tank. No leak volume is suggested for SST B-105.

3.2.4 Single-Shell Tank 241-B-107

SST B-107 was categorized as of questionable integrity because of in-tank liquid-level decreases in 1969 (GJ-HAN-128, *Tank Summary Data Report for Tank B-107*; SD-WM-SAR-006). No waste transfers are documented from fourth quarter 1963 through second quarter 1969 (LA-UR-97-311). However, a number of unexplained liquid-level increases were reported during this period as well as liquid-level decreases. Changes in liquid levels could have resulted from undocumented waste transfers or faulty liquid-level measurements. Over the period from 1964 through 1969, a maximum leak volume of 14,000 gal was projected (RPP-7389). However, the tank waste status summary data indicates a maximum decrease of 22,000 gal from SST B-107 from 1964 through 1969 (see RPP-17702 for a detailed discussion on SST B-107 waste history and RPP-17702, Appendix A for waste levels). SST B-107 contained ~264,000 gal of PUREX coating removal waste (transferred from SST C-102 in third quarter 1963) and ~270,000 gal of 1C/CW sludge and concentrated TBP Plant waste during 1964 through 1969.

The spectral gamma logging data show significant gamma activity (about 1,000 pCi/g of ^{137}Cs) at the level of the tank base in drywell 20-07-02. The activity also includes ^{60}Co, ^{154}Eu, and ^{152}Eu. Two drywells on the other side of the tank (20-07-08 and 20-10-02) have some near-surface ^{137}Cs contamination (< 10 pCi/g) and apparent deep (70 to 85 ft bgs) ^{90}Sr contamination. The ^{90}Sr contamination may have come from a near-surface leak between SSTs B-110 and B-111. The ^{90}Sr plume is discussed in Section 3.2.5 for SST B-110.

3.2.5 Single-Shell Tank 241-B-110

In 1981, SST B-110 was classified as a confirmed or suspected leaker with an estimated leak volume of 10,000 gal based on a liquid-level decrease (SD-WM-SAR-006).

The spectral gamma logging data reported in GJO-131 show massive contamination in drywell 20-10-12 from 25 ft to 100 ft bgs. From 25 to 60 ft bgs, only ^{137}Cs is identified with possible ^{90}Sr from 60 to 100 ft bgs. Drywell 20-10-02 shows "possible Sr-90" (GJO-131) from 70 to 80 ft bgs. This pattern of activity indicates a source near the cascade line between SSTs B-110 and B-111. It is likely a strontium plume emanating from the cascade line between SSTs B-110 and B-111 spreads out to drywells around SSTs B-107, B-108, and B-111 (GJ-HAN-131, *Tank Summary Data Report for Tank B-110*; and RPP-7884). The origin of the ^{90}Sr plume remains unclear. Vadose zone characterization data the ^{90}Sr is associated both fluoride and carbonate as principal anions with almost no mobile constituents such as nitrate or ^{99}Tc. None of the identified waste types transferred to SST B-110 are consistent with the apparent waste composition based of field characterization data (RPP-10098).

3.2.6 Single-Shell Tank 241-B-111

SST B-111 is considered an assumed leaker, but no leak volume estimate for this tank has been made. SST B-111 was categorized as of questionable integrity in 1978 because of the initial gross gamma data collected from drywells 20-11-09 and 20-12-06 in 1973 (GJ-HAN-132, *Tank Summary Data Report for Tank B-111*). The gross gamma activity was thought to have been associated with an unexplained in-tank liquid-level decrease of 3.1 in. that occurred between March 1972 and June 1973. Information from GJ-HAN-132 is inconsistent with data from the waste transfer records (LA-UR-97-311). The waste transfer records show that 260,000 gal of supernatant were removed from SST B-111 in the first quarter of 1972. In the second quarter of 1972, waste volume increases were noted (5,000 and 17,000 gal, respectively). In the fourth quarter of 1972, a 14,000-gal decrease in waste volume was noted. These waste volume changes may be related to the difficulty of measuring waste levels in tanks containing a surface solids layer. No changes were noted in surface level until the tank was saltwell pumped in 1983.

The spectral gamma logging data from the two drywells (20-11-09 and 20-12-06) are different. The gamma activity in drywell 20-12-06 is primarily from ^{90}Sr between 40 and 50 ft bgs. Drywell 20-11-09 had very little activity in it when spectral gamma logging was done in 1999. A very small peak (about 2 pCi/g) was noted at 37 ft bgs. In the analysis of historical gross gamma activity in drywell 20-11-09, it is noted that there was high gross gamma activity in this drywell without the identification of gamma-emitting radionuclides by spectral gamma logging (HNF-5433). It is suggested that ^{90}Sr may be present in the soil around this drywell. It is likely the ^{90}Sr in drywells around SST B-111 are closely associated with the ^{90}Sr plume around SST B-110. No leak volume is suggested for SST B-111.

3.2.7 Single-Shell Tank 241-B-112

According to the waste transfer records, SST B-112 received wastes very similar to SSTs B-110 and B-111 until the beginning of 1972 when it became an "ITS bottoms and recycle" tank. SST B-112 was declared an assumed leaker in 1978 because gamma activity had been detected in a borehole associated with this tank (GJ-HAN-133, *Tank Summary Data Report for Tank B-112*). A leak volume of 2,000 gal is listed in HNF-EP-0182. The only drywell around

SST B-112 showing significant activity is drywell 20-12-06, that has “probable ^{90}Sr” (GJ-HAN-133) from 40 to 48 ft bgs. This drywell was discussed in Section 3.2.6 dealing with SST B-111.

3.2.8 Single-Shell Tanks 241-B-201, B-203, and B-204

Four 55,000-gal capacity (200-series) tanks were constructed at the same time other tanks in the B tank farm were constructed. The four tanks received low-activity waste (LAW) from the 224-B facility. The final plutonium cleanup steps were completed in this facility, thus the waste streams were very low in beta-gamma activity but likely contained some alpha-emitting radionuclides. Thus, there are no drywells installed around the 200-series tanks for gamma logging.

According to the waste transfer records, unexplained liquid-level drops in these tanks were minimal. However, SSTs B-201, B-203, and B-204 are classified “assumed leakers” with estimated leak volumes of 1,200, 300, and 400 gal, respectively (HNF-EP-0182, SD-WM-SAR-006). These leak volume estimates were based on decreases in liquid levels in these tanks. Documentation of the technical details for these estimates was not available. However, the B tank farm 200-series tanks were used as short-term holding tanks for LAW in 224-B facility. After there had been sufficient time for the solids to settle, the supernatant was sent to cribs. Ground disposal records indicate that ~44.6 E+06 L (~11.3 million gallons) of 224 waste was discharged from the B-200 series tanks to cribs 241-B-1 and 241-B-2 from 1946 through June 1954 (HW-33591, *Summary of Liquid Radioactive Wastes Discharged to the Ground – 200 Areas July 1952 through June 1954*, pg 3) and an additional 1.7E+06 L (~0.5 million gallons) of waste was transferred from these tanks to the cited cribs from July 1954 through December 1956 as a result of flushing activities at 221-B Plant and 224-B Building (HW-48518). Thus, the estimated leak volumes from the three B tank farm 200-series tanks is < 0.02% of the total volume of 224-B facility supernatant discharged from these tanks to nearby cribs. Current leak estimates were not changed.

3.2.9 Single-Shell Tank 241-BX-101

SST BX-101 was classified as an assumed leaker in 1972 based on unexplained drywell activity observed near the tank, but no leak volume estimates have been made (HNF-4872). The leak history for SST BX-101 indicates that the SST BX-101 leak originated from a pump pit on the dome of the tank (RPP-10098). There were extensive volumes (about 25 Mgal) of waste moved through this tank from 1968 until the end of 1972. It is currently believed that there was an active leak from the SST BX-101 pump pit over this 4-year period and that the suspected leak from SST BX-102 in the early 1970s (ARH-2035, *Investigation and Evaluation of 102-BX Tank Leak*) came from the SST BX-101 pump pit (RPP-10098). It has been speculated that the SST BX-101 pump pit leak volume may have been very large based on the size of the plume indicated from spectral gamma logging data (RPP-10098).

A leak volume estimate for SST BX-101 of 4,000 gal was used based on waste transfer records (RPP-7389).

3.2.10 Single-Shell Tank 241-BX-102

SST BX-102 is listed as a confirmed leaker with a 70,000-gal leak volume (HNF-EP-0182, SD-WM-SAR-006). There is now evidence (that became publicly available in the mid-1990s) that SST BX-102 was overfilled in 1951 and this overfill event resulted in the loss of an estimated 91,600 gal of metal waste to the soil (HW-20438, pg 51, *Hanford Works Monthly Report for February 1951* and HW-20742, *Loss of Depleted Metal Waste Supernatant to Soil*). The spectral gamma logging data show a ^{238}U plume from the tank overfill event and a complex array of gamma emitting radionuclides likely from the SST BX-101 pump pit leak. A leak volume estimate of 91,600 gal was determined (RPP-10098).

3.2.11 Single-Shell Tanks 241-BX-108, BX-110, and BX-111

These three tanks are listed as confirmed or assumed leakers. SST BX-108 is listed as having leaked 2,500 gal (HNF-EP-0182, SD-WM-SAR-006). Although the waste transfer records do not include unexplained liquid-level decreases for SSTs BX-110 and BX-111, there are many contaminated drywells around these tanks (GJO-HAN-19, *Hanford Tank Farms Vadose Zone: BX Tank Farm Report*). A number of near-surface leaks have been reported (Section 5.0). Additional field investigations around these tanks are scheduled. No leak volumes are suggested for SSTs BX-110 and BX-111.

3.2.12 BY Tank Farm Contamination Estimates

SSTs BY-103, BY-105, BY-106, and BY-108 are classified as assumed leakers based on low levels of unexplained activity in nearby drywells (HNF-EP-0182).

SST BY-103 was declared a leaker based on drywell activity only with a leak volume of < 5,500 gal (HNF-EP-0182). Drywell monitoring data (drywell 22-03-09) shows ^{137}Cs activity only near the surface indicating that the contamination may have come from a near-surface leak associated with a leak detected in early 1973 when the tank contained about 14 ft of wet salt. After removing approximately 44,000 gal of saltwell liquor, future ^{60}Co activity increases found near the tank base may be attributed to migration from the cesium activity source (OR-74-106, *Increasing Radioactivity in Dry Well 22-03-09 at Tank 103-BY*).

Little data was available and no leak volume estimate has previously been developed for SSTs BY-105 and BY-106. These tanks were listed as assumed leakers based on minor increases in drywell activity. No liquid-level decreases were noted and occurrence reports indicated several alternate sources for contamination detected in drywells near these tanks

(OR-74-117, *Symptoms of Leakage at Waste Tank 105-BY as Indicated by Increasing Dry Well Radiation Levels*).

SST BY-107 is classified as a confirmed leaker based on an unexplained liquid-level decrease with a leak volume of 15,100 gal (HNF-EP-0182). A 1974 occurrence report (OR-74-27, *Significant Liquid Level Decrease – Tank 241-107-BY*) notes that the liquid level decreased beyond that expected due to surface crusting and exhauster operation and radiation peak readings were observed in a drywell near the northeast quadrant of the tank. The tank was shut down in June 1973 and approximately 167,000 gal of liquid were removed from the tank during April 1974. The surface level appeared to stabilize after pumping. However, accelerated removal of liquids continued as a precaution. The 1975 increases in drywell activity were probably caused by redistribution of contamination in the soil. Drywells on the east side of SST BY-107 show a high amount of moisture in the soil attributed to moisture intrusion from a nearby french drain and a raw water outlet between SSTs BY-104, BY-105, BY-107, and BY-108 (OR-75-56, *Increasing Dry Well Radiation Adjacent to Tank 107-BY*).

SST BY-108 is classified as a confirmed leaker with a leak volume of < 5,500 gal based on high radiation readings, frequent scintillation-probe checks, coupled with neutron-probe readings revealed an active leak near the bottom and northerly quadrant of the tank in June 1971 (PPD-453, *Monthly Status and Progress Report*, June 1971 P. AIV-18). Pumping started January 1972.

The spectral gamma logging data provide evidence that waste-loss events in the BY tank farm originated from within 25 ft of the ground surface. The vadose zone of this tank farm is highly contaminated with ^{137}Cs near surface while deeper gamma activity comes from ^{60}Co.

Most BY tank farm drywells were installed in the early to mid-1970s. In the 1970s, high levels of gross gamma activity were observed near or below the base of a number of BY tank farm tanks. The high levels of gross gamma activity near or below the base of these tanks were interpreted as strong evidence for leaks from any nearby tank. However, the spectral gamma logging data (GJO-HAN-6, *Vadose Zone Characterization Project at the Hanford Tank Farms, BY Tank Farm Report*) provides a significantly different interpretation. In the year 2000, the activity near and below the base of the tanks in the BY tank farm was ^{60}Co. The historical gross gamma logging data were evaluated in *Analysis of Historical Gross Gamma Logging Data from BY Tank Farm* (HNF-3532) in 1999. Their analysis showed that many of the drywells had high levels of ^{60}Co, ^{106}Ru, and ^{125}Sb activity near and below the base of a number of tanks in the mid- and late-1970s. Almost all of the high ^{137}Cs activity was between 0 and 20 ft bgs. Based on our current understanding of ^{137}Cs migration in the Hanford subsurface, these data demonstrated that the waste-loss events in the BY tank farm originated in this region between 0 and 20 ft bgs. The leak volumes reported for BY tank farm tanks appear to have been developed a decade or more after the initial concern about high gamma activity was observed in drywells within this tank farm (when the tanks were flagged as potential leakers) and are questionable. Therefore, a total BY tank farm vadose zone ^{137}Cs inventory estimate was developed from spectral gamma logging data. Results from this approach are reported below. The total ^{137}Cs activity can be used to develop inventories for other chemicals and radionuclides.

The BY tank farm spectral gamma logging data (GJO-HAN-6) identify four regions of high ^{137}Cs gamma activity (i.e., at > 1E + 04 pCi/g). The decay date for these ^{137}Cs estimates is 1996 (the date data was collected). The four regions are:

1. Drywells 22-08-01 and 22-08-02 from 2 to 7 ft bgs at 1E + 05 pCi/g (assume a 50-ft diameter circular plume).

2. Drywell 22-05-01 from 0 to 3 ft bgs at 1E + 04 pCi/g (assume a 25 ft circle).

3. Drywell 22-12-03 from 5 to 7 ft bgs at 1E + 04 pCi/g (assume a 25 ft circle).

4. Drywell 22-03-05 from 27 to 45 ft bgs at 3E + 03 to 4E + 07 pCi/g (assume a 25 ft circle).

5. Finally, there is the generally contaminated region from 0 to 10 ft bgs all across the BY tank farm at < 1E + 02 pCi/g.

Assuming an average soil density of 1.8 g/cc, 1 ft^3 equals 2.832E + 04 cm^3, thus, 1 ft^3 would contain 5.1E + 04 g of soil. A 25 ft circle of cesium contamination with a 1 ft depth would contain 491 ft^3 or 2.5E + 07 g of soil. A 50 ft circle 1 ft thick would include 1,964 ft^3 or 5.561E + 07 cm^3 or 1.0E + 08 g of soil. A 5-ft thick plume would include 5.0E8 g of soil.

1. Drywells 22-08-01 and 22-08-02 from 2 to 7 ft bgs at 1E + 05 pCi/g (assume a 50-ft diameter circular plume). A ^{137}Cs activity of 1E + 05 pCi/g would lead to an estimate of 50 Ci of ^{137}Cs in this plume.

2. Drywell 22-05-01 from 0 to 3 ft bgs at 1E + 04 pCi/g (assume a 75 ft circle). This leads to an estimate of 0.25 Ci of ^{137}Cs in this plume.

3. Drywell 22-12-03 from 5 to 7 ft bgs at 1E + 04 pCi/g (assume a 25 ft circle). This leads to an estimate of 0.5 Ci of ^{137}Cs in this plume.

4. Because of the depth and activity variations in the plume associated with drywell 22-03-05, a "layer cake" model was used to develop the inventory estimate. The "layer cake" model for drywell 22-03-05 assumes a 25-ft diameter circle. According to the layer cake model:

   - From 27 to 32 ft bgs, ^{137}Cs activity = 2E + 04 pCi/g. This leads to an estimate of 2.5 Ci of ^{137}Cs.

   - From 32 to 34 ft bgs, ^{137}Cs activity = 1E + 06 pCi/g. This leads to an estimate of 50 Ci of ^{137}Cs.

   - From 34 to 35 ft bgs, ^{137}Cs activity = 4E + 07 pCi/g. This leads to an estimate of 1,000 Ci of ^{137}Cs.

- From 35 to 37 ft bgs, ^{137}Cs activity = 1E + 06 pCi/g. This leads to an estimate of 50 Ci of ^{137}Cs.
- From 37 to 45 ft bgs, ^{137}Cs activity = 1E + 04 pCi/g. This leads to an estimate of 2 Ci of ^{137}Cs.
- The "layer cake" model estimate for the plume around drywell 22-03-05 leads to an estimate of approximately 1,100 Ci of ^{137}Cs.

5. Finally, there is the generally contaminated region from 0 to 10 ft bgs all across the BY tank farm at < 1E + 02 pCi/g. Assume tank farm is 300 by 400 ft. The total volume is 1.2E + 06 ft^3. This leads to 6.12E + 10 g of soil. At a uniform activity of 100 pCi/g leads to an estimate of 6.1 Ci of ^{137}Cs.

This analysis leads to an estimate of approximately 1,160 Ci of ^{137}Cs in the BY tank farm vadose zone. Volumes and inventories for other waste constituents will be developed from a knowledge of waste types in these tanks at the times of waste-loss events using the SIM. For comparison, a BY tank farm vadose zone ^{137}Cs inventory estimate of approximately 30 Ci is provided in *Addendum to the BY Tank Farm Report*, (GJO-HAN-6) September 2000. Thus, the current ^{137}Cs inventory estimate is considerably more conservative than that provided in the MACTEC-ERS report.

3.3 LEAK VOLUME ESTIMATES FOR C TANK FARM

Three of the C tank farm 100-series tanks (SSTs C-101, C-110, and C-111) and all four of the 200-series tanks are classified as assumed leakers (HNF-EP-0182). Although not classified as an assumed leaker, a high-activity cesium plume is located near SST C-105. Leak volume estimates for SST C-105 or ancillary equipment are also included in performance assessments.

An overall assessment of the spectral gamma logging data from C tank farm drywells indicates that most vadose zone contamination originated from surface or near-surface sources. This is demonstrated by relatively high concentrations of ^{137}Cs near the surface and a general decrease in ^{137}Cs activity with depth. Cobalt-60 is found near the bottom of many of the drywells with near-surface ^{137}Cs contamination. This indicates that "mobile" ^{60}Co was driven down by recharge.

3.3.1 Single-Shell Tank 241-C-101

A leak volume estimate of 20,000 gal has previously been assumed for SST C-101 (HNF-EP-0182, SD-WM-SAR-006). Decreases in waste levels were documented in the late 1960s, a time when this tank contained aged PUREX HLW. A 20,000-gal loss of this waste type would have released approximately 127,000 Ci of ^{137}Cs (BHI-01496) — more than all of the ^{137}Cs projected to have been lost from all of the SX tank farm leaks (RPP-6285). The spectral gamma logging data from drywells around SST C-101 show little evidence of any leaks and nothing of that order of magnitude. Evaporation calculations indicate that some or all of the liquid-level decreases in the late 1960s could be attributed to evaporation caused by the continuing high-heat load of the aged PUREX HLW supernatant (RPP-20820, *Waste Retrieval Leak Evaluation Report: Single-Shell Tanks*). The waste losses in the late 1970s appear to have been associated with saltwell pumping (LA-UR-96-3860). Although the waste transfer records indicate that SST C-101 was filled above the 530,000-gal fill limit from 1964 through 1969, there is no evidence of leaks from the spare inlet ports in this tank.

Given the current understanding of fluid-flow in Hanford's unsaturated soils, it is highly unlikely that a leak volume of 20,000 gal could have gone undetected by the secondary leak monitoring (i.e., the drywell gross gamma logging) system (see discussion below). At the time of the apparent liquid losses from this tank, the tank held wastes recently transferred from A tank farm boiling waste tanks. For that mission, the first six tanks in the C tank farm were fitted with air condensers to help dissipate heat generated from radionuclide decay. During the time C tank farm tanks were used to store aged PUREX HLW supernatant, large liquid-level decreases were recorded in a number of tanks and these liquid-level decreases were attributed to evaporative cooling (WHC-MR-0132, *A History of the 200 Area Tank Farms*). Based on the waste types stored in SST C-101 at the time of the liquid-level decreases (LA-UR-97-311), there was ample heat being generated through radionuclide decay to account for all observed liquid-level decreases. Thus, evaporative cooling likely accounts for much of the liquid-level decrease in this tank. Given this information, a nominal leak volume of 1,000 gal was assumed.

3.3.2 Single-Shell Tank 241-C-105

SST C-105 is not classified as an assumed leaker (HNF-EP-0182). However, high levels of ^{137}Cs activity were found near the tank base in a nearby drywell, 30-05-07. A recent evaluation of drywell monitoring data, tank farm operations records, and transfer histories was conducted (RPP-20820). Documentation on SSTs C-104 and C-105 refer to a tank leak in the cascade line between the two tanks. Gamma-ray log data from boreholes in the region between these two tanks suggest there was a leak in this line. However, no additional documentation exists on the leak stating when it occurred, how it was first found, and how it was determined to be a cascade line leak (WHC-SD-EN-TI-185, *Assessment of Unsaturated Zone Radionuclide Contamination Around Single-Shell Tanks 241-C-105 and 241-C-106*, p.16).

The data is inconclusive as to the source of the cesium plume observed in drywell 30-05-07 due to the lack of evidence linking the cascade leaks to the drywell activity. Drywell probes were apparently saturated due to the high level of radioactivity. As a result, changes in radioactivity level due to the extensive supernatant transfers into the tank between 1974 and 1979, if there were any, could not be measured accurately.

Regardless of the source of the contamination, a contaminant plume clearly exists. Based on the size of the plume and the expected composition of the waste, if it came from the tank, a leak volume of approximately 1,000-gal was determined.

3.3.3 Single-Shell Tank 241-C-110

SST C-110 was declared an "assumed leaker" following the discovery of low levels of unexplained activity in drywell 30-10-09. A measurable decrease in the liquid waste surface was not detected. In November 1952, the cascade overflow line from SST C-110 to C-111 was noted as being plugged (see RPP-20820). The tank on filling with tributyl phosphate (TBP) plant waste failed to cascade to SST C-111, which would have filled SST C-110 above the spare inlet line. Overfilling SST C-110 with TBP plant waste in November 1952 may have caused waste to drain out of the spare inlet pipeline. Contamination detected in drywell 30-10-09 may have originated from this event. The lack of drywell activity except for ^{106}Ru, which has long since decayed and disappeared, and surface liquid-level data showing no detectable decrease for about 3 years (1972 to 1975), indicates that the contamination was small and may not have come from the tank. Three pipes and a junction box near SST C-110 also are possible contamination sources. Additional descriptions of SST C-110 and leak assessments are provided in RPP-20820. The leak volume for SST C-110 was unchanged at 2,000 gal.

3.3.4 Single-Shell Tank 241-C-111

A reported liquid-level drop in 1968 (SD-WM-TI-356) was the basis for classifying SST C-111 as an assumed leaker with a leak volume of 5,500 gal. However, no spectral gamma data from drywells around the tank show an increase in activity levels as a result of the liquid-level decreases (GJ-HAN-93, *Tank Summary Data Report for Tank C-111*). The supernatant waste present in SST C-111 from 1965 through 1969 was from ^{90}Sr purification conducted at the 201-C Strontium Semi-Works (SSW) (the SSW was formerly known as the Hot Semi-Works). The SSW waste contained primarily ^{90}Sr / ^{90}Y and ^{144}Ce. Therefore, a leak from SST C-111 would have exhibited only a very weak gamma energy signature from the ^{90}Y and may not be detectable from nearby drywells. A review of waste heat load and tank temperature data showed that liquid-level losses that lead to classification of SST C-111 as an "assumed leaker" can be substantially attributed to evaporation (RPP-20820). However, the leak estimate was not changed.

3.3.5 Single-Shell Tanks 241-C-201, C-202, C-203, and C-204

There are no spectral gamma data or well documented historical record data providing a basis for leak volume estimates for SSTs C-201 through C-204. No drywells are present near the 200-series tanks in C tank farm. Therefore, no means of identifying leaked tank waste is available. However, given their small volume, losses from these tanks are not significant to risk assessment results. Leak volume estimates of 550, 450, 400 and 350 gal from SSTs C-201, C-202, C-203, and C-204 respectively (HNF-EP-0182) should be included in risk assessments.

3.4 LEAK VOLUME ESTIMATES FOR S AND SX TANK FARMS

One of the SSTs in S tank farm (S-104) and 10 of the SSTs in SX tank farm (SX-104, SX-107, SX-108, SX-109, SX-110, SX-111, SX-112, SX-113, SX-114, SX-115) are classified as assumed leakers (HNF-EP-0182). Extensive discussions of S and SX tank farm leaks can be found in RPP-6285 and RPP-7884.

3.4.1 Single-Shell Tank 241-S-104

SST S-104 is estimated to have lost 24,000 gal, probably through a spare inlet port. Based on soil contamination levels and waste transfer records, the fluids lost were likely aluminum cladding waste. A 24,000-gal loss of REDOX cladding waste would involve the loss of approximately 550 Ci of ^{137}Cs. This level of ^{137}Cs contamination is consistent with the ^{137}Cs activity found in one nearby drywell and found in cone penetrometer pushes around this drywell (GJ-HAN-73, *Tank Summary Data Report for Tank S-104*; RPP-7884).

3.4.2 Single-Shell Tank 241-SX-104

SST SX-104 was classified as a confirmed leaker with a leak volume of 6,000 gal and a leak date of 1988 (HNF-EP-0182) based on measured decreases in tank liquid levels. However, this leak volume estimate was a "worst case" estimate based on interstitial liquid-level measurements that decreased by 4 to 6 in. over 3 years (RPP-6285). Decreases in the interstitial liquid levels could have resulted from evaporation because the tank was connected to the 241-SX sludge cooler. However, because the ventilation system for the first six tanks in the SX tank farm was routed through SST SX-109 and then to the sludge cooler, quantitative liquid losses through evaporation cannot be determined. The 6,000-gal volume is a "worst case" leak assuming no evaporation from this high-heat tank over 3 years. An analysis of the heat load generated by the wastes in SST SX-104 at the time of the liquid losses would likely support assigning at least some of these losses to "evaporative cooling" rather than a tank leak (RPP-6285). However, because this analysis is not complete, the 6,000-gal leak volume is maintained.

3.4.3 Single-Shell Tanks 241-SX-107, SX-108, and SX-109

SST SX-108 is a confirmed leaker based on drywell activity. Although previous leak estimates range from 2,400 to 35,000 gal (HNF-EP-0182, SD-WM-SAR-006), based on vadose data, the larger value appears to be a more reasonable leak volume for this tank (RPP-20820). The first leak was noted in 1964 during sodium-nitrate recovery operation (BNWL-CC-701, *Characterization of Subsurface Contamination in the SX Tank Farm*; WHC-MR-0300, *Tank 241-SX-108 Leak Assessment*). The major leak from this tank was believed to have begun in 1966 when the tank was filled with REDOX HLW. Extensive historical documentation is available for the tank leak and extensive field investigations were performed assessing this leak

(RPP-7884). As part of the WMA S-SX field investigation report (RPP-7884), a leak volume of 15,200 gal was developed for SST SX-108 based on geo-statistical (kriging) analysis of spectral gamma logging and soil analysis data (HNF-5782, *Estimation of SX-Farm Vadose Zone Cs-137 Inventories from Geostatistical Analysis of Drywell and Soil Core Data*). Given poorly defined uncertainty for the kriging analysis results, it is prudent to use the 35,000-gal leak volume developed by the Ebasco Company from historical records (WHC-MR-0300).

SSTs SX-107 and SX-109 also were classified as confirmed leakers based on drywell activity (SD-WM-SAR-006). Leak volumes for SSTs SX-107 and SX-109 were scaled to the 15,200-gal leak from SST SX-108 based on ^{137}Cs kriging analysis (WHC-MR-0301, *Tank 241-SX-109 Leak Assessment*). Leak volume estimates were increased from < 5,000 to 15,000 gal for SST SX-107 and decreased from < 10,000 to 2,000 gal for SST SX-109.

3.4.4 Single-Shell Tank 241-SX-110

SST SX-110 was classified as an assumed leaker in 1976 with a leak volume of 5,500 gal based on liquid-level decreases (HNF-EP-0182). However, neither the spectral gamma logging data (GJPO-HAN-4, *Vadose Zone Characterization Project at the Hanford Tank Farms, SX Tank Farm Report*), gross gamma logging data from the laterals (HNF-5782), or the waste transfer records (LA-UR-97-311) indicate the presence of a leak or provide a basis to determine a leak volume estimate for this tank. The liquid level decrease could be attributed, at least in part, to evaporation. Much of the uncertainty associated with leak information about SST SX-110 could be resolved by re-logging the laterals under this tank with a calibrated gamma probe. A nominal leak volume of 1,000 gal was assumed based on the minimal level of activity in the laterals directly below the tank.

3.4.5 Single-Shell Tank 241-SX-111

A leak date of 1974 was determined from gamma-ray activity measured in the laterals (RPP-7884). A leak volume of 500 gal was estimated. The waste transfer records indicate this tank was used to store boiling waste from the REDOX process until 1971. At that point the tank began receiving evaporator bottoms and REDOX ion-exchange waste from B Plant. One drywell has significant contamination in the zone from 60 to 90 ft bgs. However, the contamination is thought to be related to the leak from SST SX-108 (HNF-5782).

3.4.6 Single-Shell Tank 241-SX-112

SST SX-112 was classified as an assumed leaker in 1976 with a leak date of 1969 and a leak volume of 30,000 gal (HNF-EP-0182, SD-WM-SAR-006). The waste transfer records (LA-UR-97-311) show two liquid-level losses of 31,000 gal and 32,000 gal in the first quarter of 1969. In the same time span, three transfers of waste out of the tank were made with a total volume of 498,000 gal. The waste in SST SX-112 at the time of the suspected leak was aged REDOX HLW. Even a 1,000 gal loss of this waste type would be expected to result in higher levels of radioactivity than were measured in tank laterals (HNF-5782). The spectral gamma logging of drywells around SST SX-112 identify one drywell (41-12-02) with a ^{137}Cs gamma activity that is consistent with a tank leak profile. It has been speculated that the ^{137}Cs activity in drywell 41-12-02 originated from the nearby SST SX-108 leak rather than SST SX-112 (HNF-5782, RPP-7884). Much of the uncertainty associated with the leak information about SST SX-112 could be resolved by re-logging the laterals under this tank with a calibrated gamma probe.

Given the inconsistencies between the waste transfer records and the gamma logging data from the laterals, a nominal leak volume of 1,000 gal was assumed.

3.4.7 Single-Shell Tank 241-SX-113

The base of SST SX-113 bulged during the initial filling of this tank with REDOX HLW. The tank was pumped to a minimum heel, drywells were installed, and five laterals were placed under the tank for gross gamma logging (RPP-20420, *241-S-SX Waste Management Area Inventory Data Package*). Over a 2-year period, no activity was detected in the laterals or drywells. In 1962, 208,000 gal of low-activity condensate was transferred from SST SX-114 to SST SX-113 as a tank-leak test. A leak volume of 15,000 gal was measured during the leak test (HW-75714, *Leak Testing of the 113-SX Tank*). The tank was pumped to a minimum heel and taken out of service. The tank is classified as a confirmed leaker (SD-WM-SAR-006).

3.4.8 Single-Shell Tank 241-SX-114

Although this tank is listed as an assumed leaker, no leak volume was determined. The waste transfer records indicate that a leak was noted in 1972 when the tank was filled with evaporator bottoms and B Plant isotope recovery waste (RPP-7884). The < 1 pCi/g of ^{60}Co found in one drywell (beginning at a depth of 35 ft) supports a leak of this waste type. The ^{60}Co is likely a remnant of a near-surface spill or leak (GJPO-HAN-4). A detailed description and leak evaluation of SST SX-114 is contained in RPP-20820. No leak volume is suggested for this tank.

3.4.9 Single-Shell Tank 241-SX-115

A 50,000-gal loss from SST SX-115 is well documented (BNWL-CC-701, SD-WM-SAR-006). Extensive historical documentation is available for the tank leak (WHC-MR-0302, *Tank 241-SX-115 Leak Assessment*). A reevaluation of waste transfer records and waste types also resulted in an estimate of 50,000 gal loss for the SST SX-115 leak event (RPP-6285).

3.5 LEAK VOLUME ESTIMATES FOR T, TX, AND TY TANK FARMS

Seven of the SSTs in T tank farm (T-101, T-103, T-106, T-107, T-109, T-109, T-111), eight of the SSTs in TX tank farm (TX-105, TX-107, TX-110, TX-113, TX-114, TX-115, TX-116, TX-117), and five of the SSTs in TY tank farm (TY-101, TY-103, TY-104, TY-105, TY-106) are classified as confirmed or assumed leakers (HNF-EP-0182). Waste-loss events from SSTs T-101 and T-103 involved losses from spare inlet ports. The 115,000-gal leak from SST T-106 in 1973 was the largest waste-loss event recorded at the Hanford Site. It is well documented in *High-Level Waste Leakage from the 241-T-106 Tank at Hanford* (RHO-ST-14). No leak inventory estimates were developed for eight of the assumed tank leaks in WMAs T and TX/TY.

3.5.1 Single-Shell Tank 241-T-101

SST T-101 was classified as an assumed leaker in 1992 with a leak volume of 7,500 gal based on a liquid-level decrease (HNF-EP-0182). This tank was overfilled in the 1960s and is reported to have lost an unknown quantity of REDOX cladding waste through a defective spare inlet port in 1969 (GJ-HAN-115, *Tank Summary Data Report for Tank T-101*). The location (drywell 50-01-04) and the ^{137}Cs profile found during spectral gamma logging are consistent with waste loss through a spare inlet port. Contamination profiles in drywells 50-01-06 and 50-01-09 suggest near-surface leaks of REDOX ion-exchange waste stored in this tank in the early 1970s. Based on analysis of waste transfer records, the leak volume associated with the tank overfill event was increased to 10,000 gal and the waste composition is based on a leak in that time frame (RPP-7218).

3.5.2 Single-Shell Tank 241-T-103

A leak volume of < 1,000 gal is listed for this tank with a declared leak date of 1974 (HNF-EP-0182). The contamination around SST T-103 has been suggested to have originated from a waste loss through a spare inlet port when the tank was overfilled in 1972 and 1973 (GJ-HAN-117, *Tank Summary Data Report for Tank T-103*). The radionuclide profiles suggest a B Plant origin for the lost tank waste. Analysis of tank transfer records suggests a 3,000-gal leak volume, which will be used for risk assessments. A detailed description and leak evaluation of SST T-103 is contained in RPP-20820.

3.5.3 Single-Shell Tank 241-T-106

The largest leak from any Hanford Site tank occurred in 1973 with the loss of 115,000 gal of waste from SST T-106 (based on a 41-in. liquid-level decrease). This leak event is well documented (RHO-ST-14, SD-WM-SAR-006) and data are available from analyses of waste done at the time of the leak. Additional field characterizations are underway near this tank.

3.5.4 Single-Shell Tank 241-T-107

A detailed description and leak evaluation of SST T-107 is contained in RPP-20820. Vadose data indicates that the tank may have leaked. However, no liquid surface decreases in the tank were noted and drywell contamination is minimal. Leak volume estimates for SST T-107 may be accounted for as part of the SST T-106 plume. No leak volume is suggested for this tank.

3.5.5 Single-Shell Tank 241-T-108

Neither the spectral gamma logging data nor tank waste transfer records provide evidence of a leak from SST T-108 (RPP-7218). A leak volume of <1,000 gal was determined based on liquid-level decreases in the tank (HNF-EP-0182). Gamma activity in drywells around SST T-108 (50-08-09, 50-09-02, and 50-08-11) appears to trace back to the SST T-106 leak. A detailed description and leak evaluation of SST T-108 is contained in RPP-20820. The previous leak estimate was not changed.

3.5.6 Single-Shell Tank 241-T-109

A leak volume of 1,000 gal was assigned based on drywell activity near the tank (HNF-EP-0182). No liquid-level decreases were observed in this tank. Gamma activity in drywells around SST T-109 (50-09-01, 50-09-02, 50-08-09, 50-09-10, 50-00-09, and 50-06-06) appear to trace back to SST T-106 as the source. A detailed description and leak evaluation of SST T-109 is contained in RPP-20820. The previous leak estimate was not changed.

3.5.7 Single-Shell Tank 241-T-111

A leak volume of 1,000 gal was assigned based on a 1974 liquid-level decrease in the tank (HNF-EP-0182). Neither the spectral gamma logging data nor tank waste transfer records provide evidence of a leak or any other basis for leak volume estimates for SST T-111 (RPP-7218). The previous leak estimate was not changed.

3.5.8 Single-Shell Tank 241-TX-105

This tank was declared an assumed leaker based on activity in nearby drywells with a leak date of 1977, no leak volume was determined (HNF-EP-0182). The profile of the spectral gamma logging data does not indicate that this tank has leaked, nor do the tank waste transfer records provide evidence of a leak from this tank (RPP-7218). No leak volume is suggested for this tank.

3.5.9 Single-Shell Tank 241-TX-107

A leak volume of 2,500 gal for this tank and a declared leak date of 1984 was based on increasing activity in nearby drywells (HNF-EP-0182, SD-WM-SAR-006). The zones at 50 to 70 ft bgs in drywells 51-07-18 and 51-07-07 are contaminated with ^{60}Co and ^{154}Eu, as are other drywells between SSTs TX-103 and TX-107. SST TX-107 was used as the 242-T Evaporator feed/bottoms recycle tank in 1975, apparently handling B Plant ^{90}Sr recovery waste. The gamma plumes (i.e., ^{60}Co and ^{54}Eu) around this tank indicate a substantial leak volume. The leak volume was increased to 8,000 gal based on plume size estimates. The actual value is uncertain (RPP-7218). A field characterization program is underway around this tank.

3.5.10 Single-Shell Tanks 241-TX-110, TX-113, TX-114, TX-115, TX-116, and TX-117

These tanks are listed as confirmed or assumed leakers (HNF-EP-0182), but no leak volumes are provided and no liquid-level decreases were observed. Neither the spectral gamma logging data nor the waste transfer records provide evidence to estimate a leak volume for these tanks. Therefore, no leak volume is provided for these tanks.

3.5.11 Single-Shell Tank 241-TY-101

A leak volume of 1,000 gal for SST TY-101 and a declared leak date of 1973 were assigned based on unexplained liquid-level decreases in the tank (HNF-EP-0182). Because the drywell coverage around this tank is poor (only four wells), the spectral gamma logging data provide little insight into the extent of vadose zone contamination around this tank (RPP-7218). Spectral gamma logging data from existing drywells provide no basis for a leak volume estimate. The previous leak estimate is not changed.

3.5.12 Single-Shell Tank 241-TY-103

A leak volume of 3,000 gal and a declared leak date of 1973 were assigned based on an unexplained liquid-level decrease (HNF-EP-0182, SD-WM-SAR-006). Spectral gamma logging data from drywell 53-03-03 indicates ^{137}Cs contamination near the base of this tank that could have originated from a tank leak or from waste transfer lines. Drywells 53-03-06 and 53-03-12 have deep ^{60}Co contamination (GJO-HAN-16, *Hanford Tank Farms Vadose Zone: TY Tank Farm Report*). The combination of ^{137}Cs and ^{60}Co suggests a TBP plant or B Plant waste source (RPP-7218). This tank stored TBP waste from 1957 through early 1968. From 1968 through 1973, SST TY-103 contained PUREX and B Plant waste. The previous leak estimate is not changed.

3.5.13 Single-Shell Tank 241-TY-104

A leak volume of 1,400 gal and a declared leak date of 1981 was assigned based on an unexplained liquid-level decrease (HNF-EP-0182, SD-WM-SAR-006). Neither the spectral gamma logging data nor the waste transfer records provide a basis for estimating a leak loss or evidence of a leak from this tank. The spectral gamma logging data profiles suggest extensive near-surface (i.e., waste transfer piping) leaks (GJO-HAN-16). The previous leak estimate is not changed.

3.5.14 Single-Shell Tank 241-TY-105

A leak volume of 35,000 gal and a declared leak date of 1960 were assigned based on drywell activity and waste transfer records (HNF-EP-0182, SD-WM-SAR-006). The waste transfer records suggest a 35,000-gal leak of TBP waste in 1959. The limited number of drywells around this tank indicate gamma contamination (GJO-HAN-16) that is consistent with the loss of TBP waste. Both ^{137}Cs and ^{60}Co were found in drywells 52-03-06, 52-05-07, and 52-06-05. TBP waste was the only waste type added to this tank (RPP-7218).

3.5.15 Single-Shell Tank 241-TY-106

A leak volume of 20,000 gal and a declared leak date of 1959 were assigned based on increased drywell activity in four of five nearby wells (HNF-EP-0182, SD-WM-SAR-006). In Feb. 1972, diatomaceous earth was added to the tank in an attempt to stabilize it. SST TY-106 received waste from SST TY-105 through the cascade line. Thus, both tanks contained TBP waste. Although the waste transfer records indicate an apparent waste loss in 1959, the data are ambiguous (RPP-7218).

3.6 LEAK VOLUME ESTIMATES FOR U TANK FARM

Inventory estimates are provided for four SSTs in the U tank farm (U-101, U-104, U-110, U-112).

3.6.1 Single-Shell Tank 241-U-101

SST U-101 is listed as a confirmed leaker with a leak volume estimate of 20,000 gal based on liquid-level decreases (HNF-EP-0182, SD-WM-SAR-006). However, nearby drywells do not show gross gamma or spectral gamma activity levels that are consistent with a leak of 20,000 gal of REDOX aged HLW supernatant (GJ-HAN-33, *Tank Summary Data Report for Tank U-104*). An analysis of the heat load generated by the wastes in SST U-101 at the time of the liquid losses would support assigning some or all of the losses to “evaporative cooling” (RPP-15808). The leak volume is assumed to be 5,000 gal or less based on an estimate of a likely maximum leak volume that could go undetected (Appendix A).

Further characterization of SST U-101 is planned.

3.6.2 Single-Shell Tank 241-U-104

A 55,000 gal leak from SST U-104 occurred in the early 1950s when physical inspection of the tank interior (GJ-HAN-33) revealed a tank bottom bulge in the northeast quadrant of the tank (HNF-EP-0182, SD-WM-SAR-006). Spectral gamma-uranium activity data in 10 drywells around SST U-104 and to the southwest indicate the occurrence of a metal waste leak with SST U-104 being the source. Maximum uranium concentrations over the largest depth intervals occur in drywells 60-07-11, 60-07-10, and 60-04-08 on the south and southwest side of SST U-104. In these drywells, contamination occurs just below the tank bottom about 52 ft (16 m) bgs and extends to as much as 92 ft (28 m) bgs. Uranium-235 concentrations up to 100 pCi/g and ^{238}U concentrations approaching 1,000 pCi/g near tank bottom depth have been measured. These drywells were located closest to the leak location. Given the extent of the uranium contamination footprint in the vadose zone, the leak volume estimate may be larger than the 55,000-gal leak volume listed in HNF-EP-0182. However, pending additional characterization/analysis, the leak estimate was not changed.

3.6.3 Single-Shell Tank 241-U-110

An SST U-110 leak was reported in 1975 on the basis of increased gamma activity in drywell 60-10-07 and a liquid-level drop inside the tank (SD-WM-TI-356). The tank leak volume is estimated to range between 5,000 and 8,100 gal (HNF-EP-0182, SD-WM-SAR-006). Both spectral gamma data and the historical gross gamma record are consistent with a tank leak. An average leak volume of 6,500 gal was assumed (RPP-16608, *Site-Specific Single-Shell Tank Phase 1 RCRA Facility Investigation/Corrective Measures Study Work Plan Addendum for Waste Management Areas C, A-AX, and U*).

3.6.4 Single-Shell Tank 241-U-112

SST U-112 was classified as a confirmed leaker in 1970 with leak volume of 8,500 gal based on a liquid-level decrease (HNF-EP-0182, SD-WM-SAR-006). A review of historical leak information provided in RPP-20820, Section 4.9 indicates the leak volume may have been as much as 56,500 gal. SST U-112 appears to have leaked in a similar fashion to SST U-110. One drywell, 60-02-01, shows two distinct high ^{137}Cs concentration zones near the tank bottom between 50 and 68 ft (15 and 21 m) bgs. Concentrations exceeding 10^7 pCi/g are common and a maximum value near 10^9 pCi/g occurs near 60 ft (18 m) bgs. A second less concentrated zone occurs between 83 and 97 ft (25 and 30 m) bgs where ^{137}Cs concentrations largely fall between 10^4 and 10^5 pCi/g. The bifurcated zones could indicate more than one leak (RPP-15808).

However, pending additional characterization/analysis, the previous leak estimate was not changed.

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4.0 NEAR-SURFACE CONTAMINATION IN THE SINGLE-SHELL TANK FARMS

As part of the tank farms vadose zone characterization efforts, a series of documents have been prepared that examine the operational history of each of the SST farms:

- HNF-5231, *Historical Vadose Zone Contamination from B, BX, and BY Tank Farm Operations*,
- RPP-5957, *Historical Vadose Zone Contamination from T, TX, and TY Tank Farm Operations*,
- RPP-7494, *Historical Vadose Zone Contamination from A, AX, and C Tank Farm Operations*,
- RPP-7580, *Historical Vadose Zone Contamination from U Farm Operations*
- HNF-SD-WM-ER-560, *Historical Vadose Zone Contamination from S and SC Tank Farm Operations*,.

These documents were prepared by Fluor Federal Services; they provide an overview of the structural aspects of the tank farm operations such as waste transfer piping systems and infrastructure. These documents also provide a compilation of the UPRs within the tank farm or WMA of concern. Each of the identified UPRs has a formal report associated with it that is retrievable over the Hanford Intranet from the *Waste Information Data System Database* (WIDS).[1] Selected UPR reports (Table 4-1) applicable to tank farm WMAs were incorporated into the SIM and will be used for risk assessments.

Inventory estimates have been developed for approximately 100 UPRs in the 200 East and West areas as part of the SIM. Many of these UPRs are within or in close proximity to the SST farms.

These UPRs are considered the primary near-surface contributors to risk. Future near-surface characterization efforts are scheduled for a number of the SST farms. However, as currently scoped, these efforts will only address selected near-surface waste-loss events. General characterization to better quantify near-surface contamination within a tank farm would require a much-expanded effort.

[1] A publicly available report entitled “Hanford Site Waste Management Units Report” is prepared yearly based on selected fields from the WIDS. The most recent report of the “Hanford Site Waste Management Units Report” is available on the internet at http://www.hanford.gov/docs/rl-88-30/rl-88-30.pdf (as accessed July 26, 2004). The full title of the WIDS Data Dictionary is *Waste Information Data System Data Field Definitions and Criteria*, BHI-00933, Rev. 1, January 1999.

Table 4-1. Waste Management Area UPRs. (3 sheets)

UPR	WMA	In SIM	In WIDS	Other*	RPP-18052	Waste type	Date	Volume (gal)	Location/comments
200-E-4	B/BX/BY	1	1	--	1	Cooling Water	1951	4600	241-B-151 diversion box UPR. Assumes 1L/hr for 2 yr
200-E-74	B/BX/BY	1	1	--	1	Cooling Water	1954	4900	241-B-152 diversion box, 1 Ci spread 52 ft^2. Assumes .5L/hr for 42 yr
--	A/AX	--	--	1	--	Water	Mar-01	NA	Catch tank 241-AX-152 leak observed during integrity test
UPR-200-E-105	B/BX/BY	1	1	--	1	1C	1952	23000	BY-107 manifold header
UPR-200-E-107	C	1	1	1	--	TBP	Nov-52	5	244-CR vault
UPR-200-E-108	B/BX/BY	1	1	--	1	MW	Apr-53	1	B-102 to B-101 transfer line small spill, but visible
UPR-200-E-109	B/BX/BY	1	1	--	1	TBP	Nov-53	150	B-104 pump float jam, riser spill
UPR-200-E-110	B/BX/BY	1	1	--	1	1C	Aug-55	7900	BY-112 valve pit release, 25,000 ft^2, 20 rad/hr , 700 m^3
UPR-200-E-115	A/AX	1	1	1	1	PUREX	Feb-74	1	AX-103 pump pit spray small volume on employee and ground
UPR-200-E-116	B/BX/BY	1	1	--	1	BY Salt flush water	Nov-72	0.3	BY-112 pump pit caustic flush water, 3 rad/hr Sr and Cs
UPR-200-E-118	C	--	1	1	1	TBP	Apr-57	NA	C-107 airborne tank release caused ground contamination
UPR-200-E-119	A/AX	1	1	1	1	PUREX, AR	Dec-69	0.3	AX-104 surface contamination, contaminated tools set on ground
UPR-200-E-145	A/AX	1	--	1	--	UNH, P3	--	530	A tank farm excavation
UPR-200-E-16	C	--	1	1	--	CWP	1959	50	C tank farm transfer line leak
UPR-200-E-27	C	--	1	1	--	Rad particles	Nov-60	NA	244-CR, inside tank farm fence, windblown contamination

Table 4-1. Waste Management Area UPRs. (3 sheets)

UPR	WMA	In SIM	In WIDS	Other*	RPP-18052	Waste type	Date	Volume (gal)	Location/comments
UPR-200-E-38	B/BX/BY	1	1	1	1	B Plant CSR	Jan-68	5400	241-B-152 diversion box
UPR-200-E-47	A/AX	--	1	--	1	--	--	NA	A tank farm contamination spread, failed HEPA filter 702-A
UPR-200-E-48	A/AX	--	1	--	1	--	--	NA	A-106 pump pit, windblown contamination
UPR-200-E-6	B Farm Zone	1	1	1	1	1C	1954	7	241-B-153 diversion box, ~ 1 Ci
UPR-2000E-81	C	1	1	1	--	CWP	1969	35900	CR-151 diversion box
UPR-200-E-82	C	1	1	1	--	Cs recovery feed	1982	2600	241-C-152 diversion box
UPR-200-E-86	C	1	1	1	--	PSN	1971	18500	C tank farm line break, 6mX6m contamination, ~25,000 Ci Cs, 1.35 Ci/gal.
UPR-200-W-100	T/TX/TY	1	1	--	1	1C	Mar-54	4000	Inside TX tank farm, TX-105 to TX-118 line leak. ~10 Ci
UPR-200-W-12	T/TX/TY	1	1	1	1	1C	1951	10	Riser leak S of 242-T, inside T tank farm. A few gallons
UPR-200-W-126	T/TX/TY	--	1	1	1	--	--	NA	241-TX-153 airborne. Employee contaminated
UPR-200-W-127	S/SX	1	1	--	1	REDOX Condensate	Feb-80	30	Liquid pool from 242-S evaporator inside S tank farm fence
UPR-200-W-128	U	1	1	--	1	REDOX (R1)	Jan-71	0.3	U-103 tank pit waste line, employees cut it and were contaminated
UPR-200-W-129	T/TX/TY	1	1	1	1	1C1	Jan-71	Unknown	TX tank farm pump pit flooding, personnel contamination
UPR-200-W-17	T/TX/TY	--	1	1	1	MW	Sep-52	NA	During TX-106 pump removal, 1 g solvent wind blown

Table 4-1. Waste Management Area UPRs. (3 sheets)

UPR	**WMA**	**In SIM**	**In WIDS**	**Other***	**RPP-18052**	**Waste type**	**Date**	**Volume (gal)**	**Location/comments**
UPR-200-W-24	U	1	1	1	1	MW	Apr-53	0.3	244-UR vault release, 30-ft geyser, 30 seconds.
UPR-200-W-80	S/SX	--	--	1	1	--	--	NA	S/SX tank farm windborne
UPR-200-W-81	S/SX	--	--	1	1	--	--	NA	Radioactive specs in S/SX tank farms from contaminated equipment
--	S Farm Spill	--	--	1		R	Nov-73	NA	870-gal spill, during S-107 to S-102 transfer. Spill was remediated by removing soil. No UPR assigned

Notes:

*Other = HNF-5231 for B/BX/BY, RPP-7494 for A/AX/C, HNF-SD-WM-ER-560 for S/SX, RPP-5957 for T/TX/TY, RPP-7580 for U.

CSR = cesium recovery.
CWP = cladding waste, PUREX.
HEPA = high-efficiency particulate air (filter).
MW = metal waste.
N/A = not applicable.
PUREX = plutonium/uranium extraction.
SIM = Soil Inventory Model.
TBP = tributyl phosphate.
UPR = unplanned release.
WIDS = Waste Information Data System.
WMA = Waste Management Area.

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RPP-5957, 2000, Historical Vadose Zone Contamination from T, TX, and TY Tank Farm Operations, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.
RPP-7494, 2001, *Historical Vadose Zone Contamination from A, AX, and C Tank Farm Operations*, Rev. 0, Fluor Federal Services, Richland, Washington.
RPP-7580, 2001, *Historical Vadose Zone Contamination from U Farm Operations*, Rev. 0, Fluor Federal Services, Richland, Washington.

5.0 DISCHARGES TO CRIBS AND RETENTION TRENCHES

During the early years of Hanford Site operations, three major waste streams were discharged to the vadose zone: (1) uncontaminated aqueous wastes, such as cooling water, were discharged to surface ponds, (2) high-volume waste streams with modest radionuclide and chemical contamination were discharged to cribs (e.g., off-gas scrubber solutions, 222-B and 222-T laboratory waste, evaporator condensates). Waste streams containing transuranic elements were precipitated and discharged to the SSTs for settling before discharge of the modestly contaminated supernatant to cribs (e.g., 2C and 224 building wastes), (3) waste streams that contained isotopes with long half-lives and fission products with high radiation/short half-lives were transferred to underground SSTs. Streams of HLW were transferred to the underground SSTs. In the early 1950s, when there was a severe shortage of tank space, approximately 40.9 Mgal of tank waste associated with the bismuth phosphate process were discharged to cribs and specific retention trenches (WHC-MR-0227).

Although many of the cribs and specific retention trenches are in close proximity to SST farms, most of the cribs are outside the tank farms and it was assumed that discharges to these cribs do not impact WMA vadose inventory estimates. This assumption is based on field investigations showing that because of the high volumes of fluids discharged to the cribs, any contaminants that were not strongly sorbed by the soil in close proximity to the cribs were rapidly transferred to groundwater. An example field investigation was conducted at the B-38 specific retention trench (RPP-10098).

However, intentional discharges of tank wastes to two cribs in WMAs T and TX/TY, cribs 216-T-7 and 216-T-32, are included because of the proximity of the cribs and specific retention trenches to the tank farms. The estimated volume of waste discharged to these cribs was 2.9 Mgal from 1947 to 1955 of 2C and 224-B facility waste to crib 216-T-7 (RPP-7578, RPP-5957) and 7.7 Mgal from 1946 to 1952 of 224-B facility waste to crib 216-T-32 (RHO-CD-673, *Handbook for 200 Area Waste Sites*; RPP-5957). Inventory estimates for discharges to these cribs and trenches are presented in BHI-01496.

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APPENDIX A

DETERMINATION OF DE-MINIMUS LEAK VOLUME

There has been considerable interest in establishing a minimum leak volume that could be detected by drywell-based leak detection methodologies (RHO-ST-34, *A Scientific Basis for Establishing Dry Well Monitoring Frequencies*). The approach generally assumes a “plume” geometry of something close to a sphere and a “saturated flow” system. The concept of a saturated plume encompassing high gamma activity regions has been used as the basis for leak volume estimates (ARH-2035, “*Investigation and Evaluation of 102-BX Tank Leak*). However, a recent field investigation provided direct evidence that water discharged to the Hanford vadose zone established a plume shape controlled by the subsurface soil conditions and followed an unsaturated flow system. These data led to an understanding that fluid discharges to the soil lead to a much larger spreading of the plume than would have been predicted by earlier subsurface transport models modeling saturated flow systems. An analysis of the field data (described below) leads to the conclusion that a leak volume of 5 kgal or more of fluids containing mobile gamma-emitting radionuclides would likely be detected by most drywell monitoring systems.

Gee and Ward (PNNL-13679, *Vadose Zone Transport Field Study: Status Report*, 2001) conducted a water injection experiment at a field site originally envisioned and designed by Sission and Lu (RHO-ST-46P, *Field Calibration of Computer Models for Application of Buried Liquid Discharges: A Status Report*) in the 200 East Area near the PUREX facility. The injection experiment was conducted over a 2-month period in 2000. A series of five 4,000-L injections were conducted over a 5-week period. Moisture in the soil was monitored for an additional 5 weeks. The field site (shown in Figure 1a) included an array of 32 shallow (12 m) monitoring wells arranged over a 15 m by 15 m area. The 4,000 L aliquot of river water was injected 5 m below the surface over a 6-hr period (injection rate ~11 L/min). Using neutron probes, the initial and post-injection moisture contents were determined in 32 wells at 43 depths. All moisture monitoring data were collected within 24 hours of the injection. Geostatistical analysis of the moisture data led to a series of plumes developed from the soil moisture data. The goal of this computer analysis was to transpose this series of experimentally derived plumes to a location under a hypothetical 100-series tank such that the data from the water injections would mimic a series of 4,000 L “tank leaks”. The experimental water injections were made near the center of the array of monitoring wells. Figure 1b shows how the array of wells was transposed such that the center of the water plume would coincide with the edge of a 100-series tank. From the soil-moisture data it is clear a “water mound” developed at the injection point (see Figure 2b). It appears a zone of saturated soil developed at the point of injection, likely because of the high injection rate, and the moisture mounded up to within 2 ft of the surface during the field test. The bottom of the “tank” was superimposed approximately 4 ft into the well array, thus, simulating a leak in the sidewall near the base.

Figure 2a shows the moisture content of the soil at the Sission and Lu site prior to any water injections. The importance of the pre-injection data is they show a high-moisture zone approximately 7 m (23 ft) below ground surface (bgs) that appears to be near saturation. A second moist zone is shown approximately 2.8 m (8 ft) bgs. In the series of figures projecting simulated tank leaks, the plumes represent the change in moisture content (theta-t_n) shortly after an injection relative to the pre-injection moisture content (theta-$t_{initial}$).

Figure 1c shows the moisture plume situated at the edge of the tank after the injection of 4,000 L of water and Figure 1d shows moisture data after the third 4,000-L injection. These two figures provide some prospective of the 3-dimensional nature of the plume and of "plume growth" with the addition of fluids.

Figures 2a and 2c provide a comparison of initial moisture conditions in the soil (i.e., before any water injections) with the soil moisture 5 weeks after the last of the five 4,000-L injections. From these figures it is clear the soil moisture content is rapidly returning to its initial condition.

Figures 2b and 2d provide a comparison between total moisture in the soil shortly after a 4,000-L injection (2b) and the difference between measured moisture at time t minus the initial soil moisture.

Figures 3a through 3d provide a plan view of the moisture plume at various times. It is interesting to note that after the injection of 16,000 L the plume has reached the edge of the monitoring well array. By the fifth week after the last injection it is clear the plume has expanded well beyond the monitoring well system. Figure 3d shows a moisture plume that appears to exceed 15 m (~50 ft) diameter. This represents the maximum spread likely to be seen with a 20,000 L (5,300 gal) leak. With configuration of drywells around most of the SSTs, a leak of this magnitude would likely have been detected if the lost fluids contained mobile gamma emitters (i.e., ^{106}Ru and/or ^{60}Co). Thus, a 5,000-gal leak volume is suggested as a "maximum undetected leak volume" for SST leaks.

Clearly there are some limitations to this "maximum undetected leak volume". Because the gamma logging-based leak detection system depended on the presence of mobile gamma-emitting radionuclides, the 5,000-gal volume estimate would only apply to high-activity waste types such as the REDOX and PUREX HLW streams and B Plant isotope recovery waste streams. The gamma-logging systems were of little or no value in detecting leaks of LAW types such as the 224 wastes and aluminum cladding wastes, which contained orders of magnitude less gamma emitters. Although fine-soil horizons are ubiquitous across the soil columns in the 200 East and West areas, the occurrences of the fine-soil zones are site specific. Finally, follow-up tests at the Sission & Lu site showed that fluid spreading in the vadose zone is sensitive to the salt content of the injected material. Additional tests are planned in the S tank farm to better evaluate these phenomena.

There are field data related to a well-characterized SST leak event that provide support to the concept of extensive lateral spread of tank waste fluids. A 1973 leak of approximately 115,000 gal of B Plant cesium recovery waste from SST T-106 was extensively characterized shortly after the leak and there after (RHO-ST-14, *High-Level Waste Leakage from the 241-T-106 Tank at Hanford*). The mobile ^{106}Ru plume spread laterally to encompass an oval-shaped area of approximately 140 ft by 170 ft. The vertical spread was approximately 50 ft below the apparent leak point. The leak event is believed to have lasted 71 days or an estimated leak rate of 1.1 gal/min (4 L/min). This leak rate compares with an approximate 2.9 gal/min injection rate for the field test. The ratio of lateral to vertical spread appears to be approximately 2 for the field test and 3 for the SST T-106 leak event. Given the differences in location, fluid discharge rate, and fluid compositions involved, this is in very good agreement.

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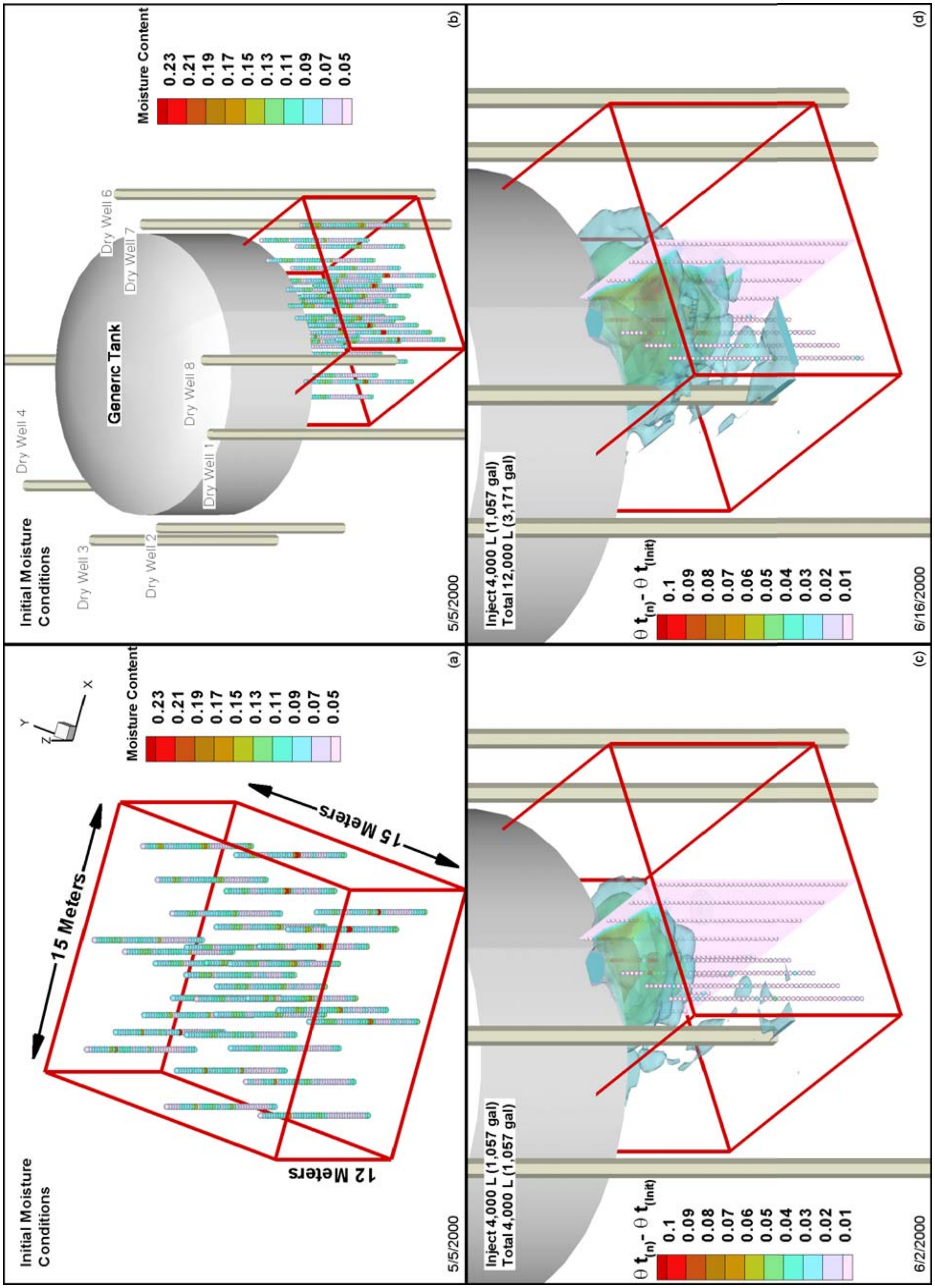
Figure 1. Monitoring Wells and Moisture Content.



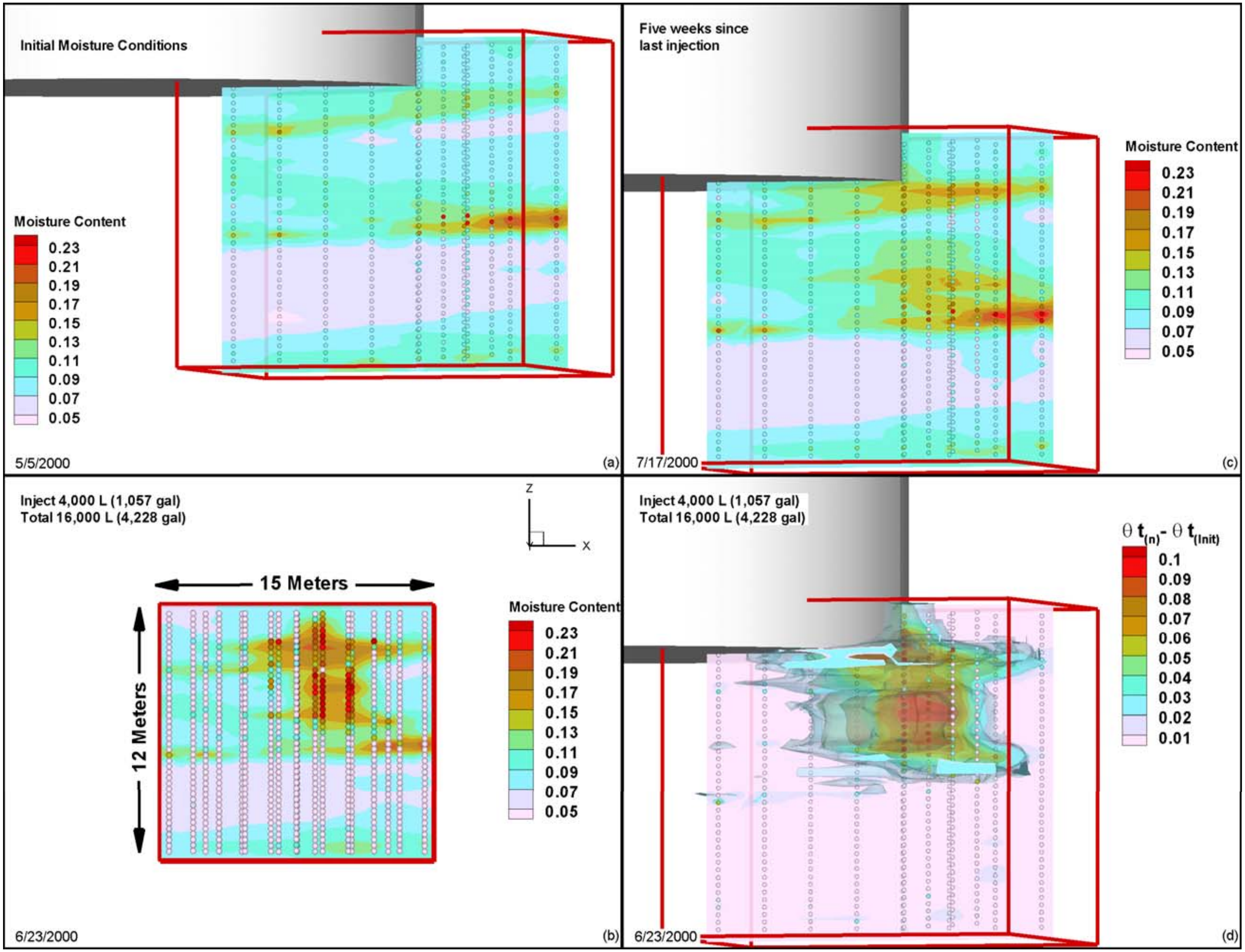


Figure 2. Moisture Plume at Various Times.

Figure 3. Plan View of Moisture Plume at Various Times.